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Characterization and classification of the *Musa* AAB Plantain subgroup in the Congo basin

J. Adheka Giria &
E. De Langhe

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Joseph Adheka Giria
& Edmond De Langhe

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2 3 JULI 2018

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PLANTENTUIN MEISE

INV. Nr apm 2273

Université de Kisangani (UNIKIS), Faculté des Sciences,
Kisangani, Democratic Republic of Congo

In collaboration with Department of Biosystems,
Faculty of Bioscience Engineering KU Leuven

Botanic Garden Meise (Belgium)

Scripta Botanica Belgica
Miscellaneous documentation published by Botanic Garden Meise
Series editor: I. Hoste
Volume editor: S.B. Janssens

Volume 54
Joseph Adheka Giria & Edmond De Langhe
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CIP Royal Library Albert I, Brussels

Characterization and classification of the Musa AAB Plantain subgroup in the Congo basin. Joseph Adheka Giria & Edmond De Langhe – Meise, Botanic Garden Meise, 2018. – xii + 104 p.; ill.; 22,6 × 16,8 cm. – (Scripta Botanica Belgica, vol. 54).

ISBN 9789492663146
EAN 9789492663146
ISSN 0779-2387
Subject: Botany
D/2018/0325/001

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Printed in Belgium by GEWA, Arendonk

Cover illustration: A French Plantain bunch. (Photograph Joseph Adheka Giria)

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Foreword

Bananas originate from Asia and are one of the first crops domesticated in the world. As a result spectacular changes occurred from the wild seeded diploid bananas to the current edible triploid bananas.

A specific subgroup of the bananas, the starchy seed sterile plantains, moved from Asia to Africa about 3000 years ago during human migrations. They underwent gigantic morphological changes in Central and West Africa. This is due to the millennia long cultivation of these plantains that have become a staple food over a large area in Africa. Hence there are many plantain varieties in Africa originating from just a few plantains in Asia.

This book fills up a vacuum in documenting the morphological diversity of plantain. It meticulously documents the features of 97 plantain varieties collected in DR Congo (Democratic Republic of Congo). The varieties were collected in the period 2005 to 2012 over almost the entire territory of DR Congo including the highlands in Eastern DR Congo. Hence plantain are not only cultivated in the lowlands as previously thought. By a systematic comparison with the varieties described elsewhere in Africa, it becomes clear that DR Congo is the centre of diversity of plantain in the world.

Banana and plantain varieties are described worldwide following a standard list of descriptors. This book documents that such efforts in plantain description are repetitive for many parameters thus rendering plantain phenotyping time consuming. The data assembled provide for the first time the opportunity in *Musa* to document the common feature of all plantain varieties and thus to define the "plantain" subgroup. As such, when phenotyping new plantain varieties in the future, one can immediately focus on those parameters that are variable among plantain varieties. This work thus paves the way for similar approaches in defining other subgroups like the "Mai'a maoli" subgroup.

The definition of the "plantain" subgroup with a set of parameters and the understanding of the variable parameters, allows the proposition of a list of plantain varieties to serve as a core set to further study the plantain diversity in Africa. This is for example useful for molecular studies to identify varietal differences at the genetic and epigenetic level. This is indeed necessary as the variation of plantain diversity in Africa was not created via hybridization.

Plantain is cultivated by many tribes in DR Congo and elsewhere. Consequently identical varieties are named differently but also a same name is given to different varieties. Therefore the exchange of information on plantain varieties is nearly impossible

because of many misunderstandings. This book therefore documents the synonymy of all collected varieties, thereby contributing to a clearer understanding of what variety is cultivated where and by whom.

This research was carried out by Dr. Joseph Adheka of the University of Kisangani (UNIKIS), DR Congo as part of his PhD research during the period 2012-2014. Prior to his PhD research, Joseph Adheka carried out a master thesis on *Musa* characterization in Oriental province of DR Congo. Both the MSc and PhD studies were conducted in the framework of a plantain germplasm characterization project supported by CIALCA-Bioversity International (Consortium for Improving Agriculture-based Livelihoods in Central Africa). He is currently assistant professor at UNIKIS.

Prof. em. Edmond De Langhe, was the first person to document the plantain diversity in DR Congo in the 1950s and set the scene for plantain taxonomy (but also for other subgroups) worldwide. He was a former scientist based at INEAC, DR Congo. His work was discontinued in the 1960s after the political unrest in DR Congo but later continued to some degree in the 1980s and beyond in Nigeria by IITA (International Institute of Tropical Agriculture) and Cameroon by CARBAP/CRBP (Centre de Recherche pour le Bananier et Plantain). He intensively collaborated to the construction of Dr. Adheka's PhD and of this book.

The foundation of this work is the result of several collecting expeditions in DR Congo in the period 2005 to 2012, most notably the characterization and collecting surveys carried out by seven UNIKIS MSc students co-supported and guided by Dr. Guy Blomme of Bioversity International. The varieties were collected over almost the entire territory of DR Congo including the highlands in Eastern DR Congo. Financial support came from DGD-Belgium through the CIALCA-Bioversity International project. Joseph Adheka's taxonomical training was provided by the Laboratory of Tropical Crop Improvement (KU Leuven, Belgium) with funds from the Flemish Inter-University Council, Belgium (VLIR) under guidance of Prof. Rony Swennen.

This book gives a new impetus to plantain taxonomy efforts and is another illustration of the continued long term research relationship on plantain with Belgium that started in DR Congo in 1933 at INEAC, Yangambi and in 1976 at KU Leuven, Belgium. The research at both locations eventually resulted in the foundation of the International banana collection at KU Leuven by Edmond De Langhe. This collection is now called Bioversity International Musa Germplasm Transit Centre (ITC).

This comprehensive overview and description of the large diversity of plantain varieties now found in DR Congo, places this diversity in the wider context of the plantain in West Africa. As such, this book presents the most recent taxonomy and classification of the numerous plantain cultivars in Africa. It is expected that references to this book will substantially improve the efficiency of research on plantains.

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KU Leuven, Belgium

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Summary

This work characterizes and classifies the plantain cultivars collected from the Congo basin of Democratic Republic of Congo (DR Congo), and assessed in a field collection at the University of Kisangani (UNIKIS). These cultivars were compared with available data from other plantain collections in the country and elsewhere in Africa to provide a comprehensive overview of plantain diversity.

Indeed, *Musa* collection and characterization work was carried out by INEAC scientists in central and eastern DR Congo during the late 1950s. Fifty-six plantain cultivars were collected by De Langhe during the 1950s in the eastern Congo Basin (Tshopo District, Oriental province, DR Congo). The *Musa* collections established in the 1950s at the INEAC Yangambi, Bambesa and Lubarika research stations currently no longer exist due to years of social unrest and instability in the region. However, the study of these collections had led to a series of publications, especially for the plantains (De Langhe, 1961a; 1961b; 1964a; 1964b) which proved to be of great help for the present work. It thus appeared feasible to resume and to complete the plantain characterization work in DR Congo, an important task since the crop is a key component to food security in the country. The operation was implemented by Joseph Adheka under the principal guidance of Edmond De Langhe.

A series of collection missions was carried out from 2005 to 2012 in the provinces of Equateur, Province Orientale, Bandundu, Maniema, Kasai (northern part) and Katanga (northern part). During this period of 7 years, 264 villages were visited and a total of 96 cultivars were collected and established in two field collections at the UNIKIS.

Plantain diversity in DR Congo shows a decrease and change in composition from tropical rainforests to savanna regions. Bunch type is the main striking difference resulting in a distinction in three main Plantain types: French, False Horn and Horn. With 63 cultivars, French plantains are most abundant, followed by False Horn plantains (23 cultivars) and Horn plantains (10 cultivars). Other distinct differences are the size of the pseudostem (giant, medium-sized, small-sized, semi-dwarf, and dwarf). These descriptors were ranked as "main" descriptors. Other descriptors (pseudostem color, immature fruit peel color, fruit shape, fruit apex, fruit position, number of hands, fruit size, number of fingers per hand and flower relics at the fruit apex) allowed for the precise differentiation among most cultivars and were ranked as "secondary" descriptors. A few "rare" descriptors were added to differentiate specific cultivars with a unique morphology.

During the 1950s, a similar field collection had been established at the INEAC research centre in Yangambi (DR Congo), and the description of its 56 cultivars published. The comparison of the descriptors of these 56 cultivars with the 97 cultivars recently collected reveals now that at least 119 plantain cultivars exist in DR Congo. Indeed, 35 accessions were found common in both collections, 61 accessions appeared unique to the UNIKIS collection and another 23 accessions unique to the Yangambi collection. Among the unique Yangambi accessions, many were dwarf/semi-dwarf cultivars. As these are of great value, the regions from where they had been collected need to be revisited for collection and deposition into the UNIKIS collection.

Plantains have been cultivated for centuries by many different tribes with their own history, and therefore many cultivars acquired different names. This widespread synonymy was investigated during the collecting missions by either direct assessment of identical morphology or field evaluation in the collection for dubious cases. This assessment allowed to link specific diversity at specific locations in the studied region. Cultivars with many recorded synonyms were logically the most widespread ones and hence of high agronomic importance. This is particularly the case for a number of False Horn plantains. Cultivars with only one synonym or none were confined to small areas in the same linguistic zones. It is noteworthy that names used by farmers in plantain taxonomy generally refer to a particular trait of a cultivar, which was of great help in cross checking names.

The significance of the 119 accessions from the Yangambi and UNIKIS collections for the entire plantain diversity in Africa was estimated by comparing with available data from other collections. At present, most of the plantains are hosted in 4 collections: Centre Africain de Recherches sur Bananiers et Plantains (CARBAP) at Nyombe (Cameroun) and International Institute of Tropical Agriculture (IITA) at Ibadan (Nigeria) for West African cultivars; UNIKIS and Université Catholique de Graben (UCG) in DR Congo for Central African cultivars. CARBAP, UNIKIS and IITA collections host cultivars adapted to lowland while the UCG collection hosts accessions that seem to be adapted to the higher altitudes. It was shown that the explored plantain diversity in DR Congo represents the vast majority of the total plantain diversity in Africa. Nevertheless, other cultivars appear to exist also in Western Africa.

As the planting of all accessions in one location is not feasible due to ecological and financial constraints, it is proposed that curators organize and maintain an intensive exchange of relevant information and discussions visits, in order to progressively reach a pan-African assessment of plantain diversity, including the multiple synonymies.

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Photo credits

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General introduction

Plantain as a staple food crop in Democratic Republic of Congo (DR Congo)

In sub-Saharan Africa, it is estimated that over 30 million people subsist on bananas as the principal source of dietary carbohydrate. The vast majority of the bananas traditionally cultivated in West and Central Africa are plantains, of which the starchy fruits need culinary preparation for consumption. The rest consists of dessert and other cooking bananas (FAOSTAT, 2010). The major part of plantains produced in sub-Saharan Africa is for local consumption, as less than 3% is exported (Karamura *et al.*, 1999).

Compared to other staple crops, banana and plantains ranked second in terms of production after cassava according to the DR Congo national statistics. Oriental Province ranked first with about 30% of banana and plantain production. The entire production is consumed locally after frying, or as a donut or dried and processed into flour to make a very popular paste (Onautshu, 2007, Adheka *et al.*, 2013).

Most banana and plantain producers are small scale farmers growing the crop mainly for home consumption or for local markets. Nonetheless, with increasing urbanization, bananas and plantains are becoming more and more important as cash crops, in some cases providing the only source of income to rural populations, thus playing an important role in poverty alleviation (Karamura *et al.*, 1999).

In DR Congo, bananas and plantains are grown at different altitudes and in different crop mixtures on large and small farms. Plantains are more widely grown in the hot and humid climates of the lowland regions at 0-750 m above sea level (masl), which correspond with the provinces visited by the UNIKIS missions, i.e. Equateur, Province Orientale, Bandundu, Maniema, Kasai (northern part) and Katanga (northern part). To the east of DR Congo, and at higher altitudes in North and South Kivu provinces, the landscape is mostly occupied by the East African highland bananas (AAA-EA), while different dessert bananas dominate in the savannah regions of Bas Congo, southern Katanga, southern Kasai and southern Bandundu (Adheka *et al.*, 2013).

Plantains are grown in backyards or in fields established after a fallow or in the forest. In the latter systems, plantains are associated with other staple crops such as maize, rice and cassava. However, the main cropping system in urban and rural environments

is the backyard system where plantains are associated with various other crops around houses to provide food self-sufficiency (Onautshu, 2007; Adheka, 2010).

The challenges for exchanging research information on plantains

The productivity of plantains in traditional farming is seriously limited by soil depletion, lodging by winds, diseases and pests, and socio-economic constraints (Dhed'a *et al.*, 2011a). Yields are about one third of the yield potential. Such deficiencies call for selection of the most performing cultivars and their genetic improvement. This is a massive task as there are many cultivars because it is postulated that many somatic mutations have been generated precisely in DR Congo because plantain constitutes a staple food for the majority of tribes in the humid zone of the Congo basin, and may have been so for many centuries. Consequently results on one or even a few cultivars are not representative for all plantains. We propose to call this *"the taxonomic handicap"*. There is thus the need for a taxonomic reference database that allows the univocal identification of a cultivar under investigation.

In addition, each cultivar has a local vernacular name in a given area. Hence each popular cultivar has as many different names as there are tribes that cultivate it. Consequently research results on cultivars, when published with their local name, can hardly be understood in other areas. We propose to call this *"the synonymy handicap"*.

Despite earlier research on plantains (Chapter 2), these two problems are not resolved because only part of the diversity in DR Congo had been studied and classified.

Addressing the double handicap

This work postulates that both the *taxonomic* and *synonymy handicap* could be resolved in the UNIKIS collection, provided that most of the existing diversity has been assembled. More precisely, this work is based on the following double hypothesis: (a) that an adequate description of plantain cultivars can be achieved by establishing a description of the entire subgroup supplemented with the characterization of all the cultivars, (b) that an exhaustive assessment of the multiple synonymy will rule out confusion on the identity of cultivars in experimental trials.

This undertaking has a great significance to *Musa* taxonomy in general because for most of the about 30 subgroups of edible bananas, the identity is characterized by one or a few cultivars. The variation of characters seen among many cultivars per subgroup is so far not described and classified, although some variants can be of local-to-global economic interest. It will be demonstrated how a new taxonomic implementation of the Plantain subgroup can serve as a model for all the other subgroups.

In Chapter 1, a literature review provides the taxonomic background on bananas and places the plantain subgroup in the context of edible bananas in general. This is followed by a review of previous and present relevant research on plantain taxonomy in Africa in Chapter 2. The same Chapter explains the methodology via several collecting missions that covered a period of seven years and the establishment of the collected plantain cultivars in two field collections at the UNIKIS, and the inventory thereof. The attempt to provide a clear definition of the plantains as a subgroup is discussed in Chapter 3. In Chapter 4, a newly adopted systematic description of the 96 conserved accessions is presented. Chapter 5 deals with the synonymy problem and provides an outlook on the plantain diversity at the continental scale as well as on the need for a standardized nomenclature. The salient achievements are reviewed in the Conclusion.

Bananas and Plantains

Taxonomy of the bananas

Bananas are herbaceous monocotyledons. They belong to the family of Musaceae, a member of the order Zingiberales, together with the families Cannaceae, Heliconiaceae, Costaceae, Marantaceae, Zingiberaceae, Lowiaceae, and Strelitziaceae (Janssens *et al.*, 2016). The Musaceae have many similarities with these families, especially with the Strelitziaceae.

The Musaceae consist of three genera: *Musella*, *Ensete* and *Musa*. The genus *Musa* is widely distributed in Southeast Asia and consists of four sections, with basic chromosome numbers between nine and fourteen (Swennen and Rosales, 1994). The four sections are *Callimusa*, *Rhodochlamys*, *Australimusa*, and *Eumusa*, the latter two including both seeded and edible types. A recent proposal, based on molecular grounds, to merge *Eumusa* with *Rhodochlamys*, and *Callimusa* with *Australimusa* (Wong *et al.*, 2002), has no implications on the classification of edible bananas. *Eumusa* is the biggest section and the most geographically widespread, with wild species being found from India to the Pacific islands. The section contains at least 11 species (Horry *et al.*, 1997), among which *Musa acuminata* and *Musa balbisiana* are the wild ancestors of almost all edible bananas.

Edible bananas differ from their wild relatives by being seedless and parthenocarpic the fruit pulp develops without pollination and is thus seedless. They are cultivated throughout the humid tropics and subtropics in the Americas, Africa and Asia (each representing about one third in production), extending into Europe (Canary Islands) and Australia (Queensland) (Heslop-Harrison and Schwarzacher, 2007). The number of edible varieties (cultivars) has been estimated at more than 600 and displays a considerable morphological and genetic diversity.

The impressive diversity in *Musa acuminata* forms and genotypes resulted in the considerable morphological diversity of edible bananas. *Musa balbisiana* is much less variable. The *M. acuminata* diversity has been classified in subspecies, but some uncertainty exists. Currently, and based on phenotypic traits and genetic behavior, the following subspecies are recognized in *acuminata*: *banksii*, *burmannica*, *errans*, *malaccensis*, *microcarpa*, *siamea*, *truncata* and *zebrina* (Simmonds 1962, Boonruangrod *et al.*, 2008).

Several of these subspecies were involved in the domestication process that eventually generated the edible bananas (Carreel *et al.*, 2002; Boonruangrod *et al.*, 2009; Perrier *et al.*, 2009). The initial edible diploids of the New Guinea-based *banksii* subspecies

played a primary role in the development of many hybrid diploid cultivars in Southeast Asia, via natural crosses with other *M. acuminata* subspecies. Subsequently, natural backcrosses with *M. acuminata* or with *M. balbisiana* produced the triploid cultivars (Perrier *et al.*, 2011; De Langhe *et al.*, 2010).

The term 'plantain' became used for starchy bananas that need cooking are roasting before consumption, in contrast with the so-called dessert bananas. Such distinction has no botanical meaning and, as is explained in the next item, the banana research community follows the recommendation by Simmonds (1959) to use the term exclusively for a distinct subgroup of starchy bananas.

The classification of the edible banana diversity in groups and subgroups

Groups

Based on a numerical scoring system involving 15 characters, with a score 1 for pure *acuminata* expression to 5 for pure *balbisiana* expression, the relative contribution in genomes of each species has been estimated for a wide range of cultivars (Simmonds and Shepherd, 1955). Preliminary ploidy assessment is necessary. Characters used in the taxonomic scoring of banana cultivars are given in Table 1.1. With 'A' standing for the *acuminata* genome and 'B' for the *balbisiana* genome, the authors classified the diploid and triploid cultivars in 6 groups on the base of the obtained total scores per cultivar: AA and AAA = 15-23; AAB = 24-46; AB = around 49; ABB = 59-63; ABBB = around 67. This scoring system has since been widely applied.

The same authors proposed a phylogeny for the corresponding groups, of which a recent version is shown in Fig 1.1.

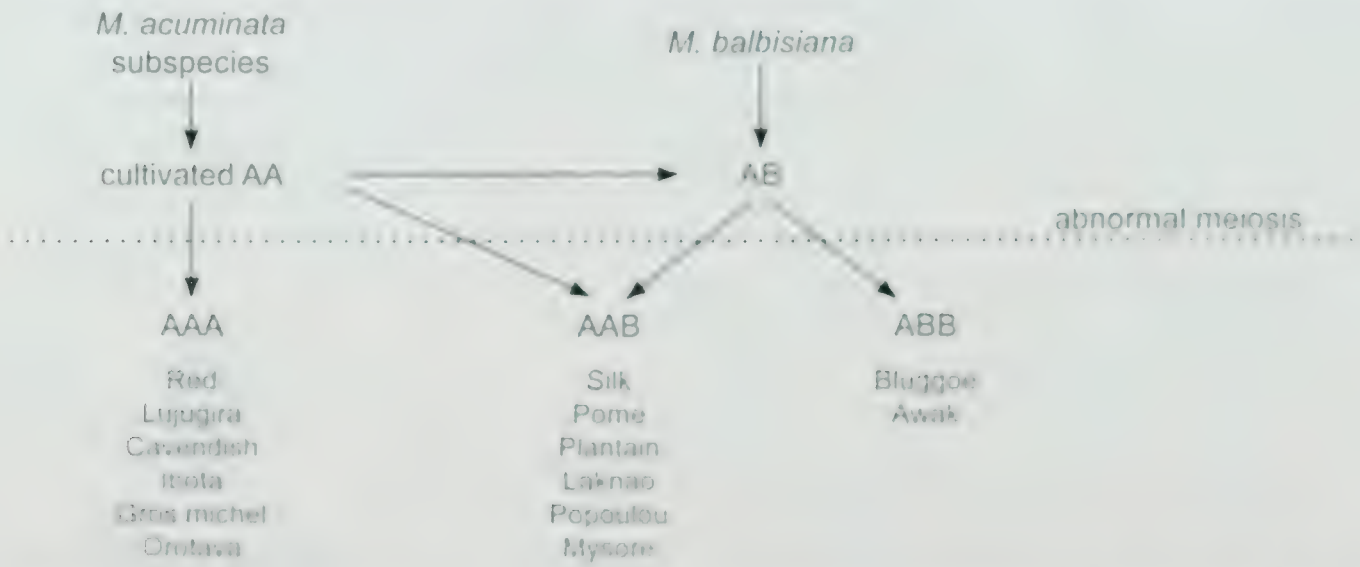


Figure 1.1. Reconstructed origin of edible bananas. (Adapted from Lanaud *et al.*, 1992 in Swennen and Rosales, 1994.)

Table 1.1. Descriptors for the classification in Groups.

Descriptor	*Musa acuminata*	*Musa balbisiana*
Pseudostem color	More or less heavily marked with brown or black blotches	Blotches slight or absent
Petiolar canal	Margin erect or spreading, with scarious wings below, not clasping pseudostem	Margin enclosed, not winged below, clasping pseudostem
Peduncle	Usually downy or hairy	Glabrous
Pedicel	Short	Long
Ovule	Two regular rows in each loculus	Four irregular rows in each loculus
Bract shoulder	Usually high x/y ratio < 0.28	Usually low x/y ratio > 0.30
Bract curling	Bracts reflex and roll back after openingw	Bracts lift but do not roll
Bract shape	Lanceolate or narrowly ovate, tapering sharply from the shoulder	Broadly ovate, not tapering sharply
Bract apex	Acute	Obtuse
Bract color	Red, dull purple or yellow outside; pink, dull purple or yellow inside	Distinctive brownish-purple outside; bright crimson inside
Color fading	Inside bract color fades to yellow towards the base	Inside bract color continuous to base
Bract scar	Prominent	Scarcely prominent
Free tepal of male flower	Variably corrugated below tip	Rarely corrugated
Male flower color	Creamy white	Variably flushed with pink
Stigma color	Orange or rich yellow	Cream, pale yellow or pale pink

The following groups are currently recognized in edible bananas and hybrids: diploids AA, AB, and possibly BB; triploids AAA, AAB, ABB, and possibly BBB; and tetraploids AAAA, AAAB, AABB, and ABBB. Plantains belong to the AAB group (Swennen and Rosales, 1994).

Subgroups

Within each group, banana cultivars that share a large number of similar characteristics are considered to have arisen from the same hybrid (and its possible siblings) by somatic mutation and thus to belong to a same subgroup. Table 1.2 gives the classification of edible bananas into groups and subgroups and their fruit types.

Several subgroups consist of a large number of cultivars. For example, the AAB Plantain subgroup contains probably more than 119 cultivars (Chapters 4 and 5). Somatic variation is considered to be at the origin of this intra-subgroup diversity. Indeed,

farmers have vegetatively propagated (cloned) the original cultivars for centuries if not millennia, and that propagation must have caused many somatic mutations (De Langhe *et al.*, 1994-5). Beyond the plantains, some subgroups with 'cooking' (starchy) fruit type are also extremely diverse and important in the diet across tropical and subtropical countries. These multiple cultivars with their corresponding diverse morphology have not been adequately documented, with the general result that no adequate description of these subgroups exists so far. Meanwhile, some salient characteristics

Table 1.2. Classification of edible bananas into groups and subgroups and their fruit types (from Lassoudière, 2010).

Group	Subgroup	Cultivar	Fruit type
AA	Sucrier	Pisang Mas, Frayssinette, Figue Sucrée	Dessert
	Pisang lilin	Pisang Lilin	Dessert
	Pisang berangan	Pisang Berangan	Dessert
	Lakatan	Lakatan	Dessert
AAA	Cavendish	Lacatan, Poyo, Williams, Grande Naine, Petite Naine	Dessert
	Gros Michel	Gros Michel, Cocos, Highgate	Dessert
	Figue rose	Figue Rose, Figue Rose Verte	Dessert
	Lujugira-Mutika	Intutu, Mujuba-Mbwazirume	Cooking
	Ibota	Yangambi Km 5	Dessert
AB	Ney Poovan	Safet Velchi, Sukari	Acid dessert
AAB	Figue Pomme	Maçà , Silk	Acid dessert
	Pome	Prata	Acid dessert
	Mysore	Pisang Ceylan	Acid dessert
	Pisang Keilat	Pisang Kelat	Dessert
	Pisang Rajah	Pisang Rajah Bulu	Dessert
	Plantain	French, False Horn, Horn	Cooking
	Pacific Plantain	Maia Maoli, Popoulou, Iholena	Cooking
	Laknao	Laknao	Cooking
	Pisang Nangka	Pisang Nangka	Cooking
ABB	Bluggoe	Bluggoe, Matavia, Poteau, Cacambou	Cooking
	Pelipita	Pelipita	Cooking
	Pisang Awak	Fougamou	Dessert
	Peyan		Cooking
	Saba	Saba	Cooking

are useful for subgroup differentiation. For example differences in pigmentation of flowers characterize AAB subgroups that resemble the plantains: the compound tepal is yellow-orange in plantains, Pisang Kelat, and Pisang Raja, while it is white with more or less washed pink, and yellow or yellow-orange lobes in the other AAB subgroups (Champion, 1967).

The still common perception that the B-genome is responsible for the starchy character of the fruit-pulp is not supported by Table 1.2. For example, the AAA group contains the well-known sweet dessert bananas of the Cavendish and Gros Michel subgroups, as well as the Lujugira-Mutika subgroup, also called "East African highland bananas", of which the fruits are cooked before ripening (although some cultivars can be also eaten as dessert when fully ripe). Similarly, the AAB group includes the plantains that are cooked or fried before consumption as well as the 'Pome' subgroup (AAB) which is widely used as a dessert banana. The difference suggests that the presence of different A genomes in AAB bananas (Ude *et al.*, 2002) and various combinations of the different A genomes produce a wide range of different characteristics (Pillay and Tenkouano, 2011).

Molecular genetics confirm the classification

Morphotaxonomy in banana has been first substantiated by chemotaxonomic studies involving isozyme and flavonoid analysis; subsequently molecular genetics used DNA-analysis techniques such as the restriction fragment length polymorphisms (RFLPs), amplified fragment length polymorphism (AFLP), random amplified polymorphic DNA (RAPDs), and more recently the highly performing marker techniques of Simple Sequence Repeats (SSR) and Diversity Arrays Technology (DArT) (Ude *et al.*, 2002). Results at molecular level have confirmed the morphological classification into groups and subgroups.

At the Group level, the identification of polymerase chain reaction (PCR) markers for the detection of A and B genome sequences in *Musa* was already reported by Pillay *et al.* (2000). Likewise, using AFLP markers on 28 *Musa* accessions of *M. acuminata* (AA) Colla and *M. balbisiana* (BB) Colla, neighbor-joining and principal co-ordinate analyses produced four major clusters that closely corresponded with the genome composition of the accessions (AA, BB, AAB, and ABB) (Ude *et al.*, 2002).

At Subgroup level, and in a recent study across 561 *Musa* accessions, the allelic distribution of 22 SSR loci was analyzed (Hippolyte *et al.*, 2012). This analysis produced the clusters that reflect the triploid subgroups, but in addition indicate the putative diploid parents in some cases.

However, neither SSR nor DArT could differentiate cultivars within subgroups. Indeed, it has been admitted, after a DArT study on taxa, that "The variation was close to nil in several groups often considered as clones with only somatic variation, such as the Cavendish group or the Plantain group"* (Risterucci *et al.*, 2009). Since even the cur-

* The authors should have used the term 'subgroup' when dealing with Cavendish or Plantain

rently used and most precise single nucleotide polymorphism (SNP) technique seems not able to differentiate the numerous plantain cultivars, it is postulated that the somatic variation is of epigenetic origin. Hence molecular tools to differentiate plantain cultivars would appear to be of no use in support of research in plantain taxonomy.

The evolution of the bananas

Edibility of the diploid *M. acuminata* (AA), which evolved primarily in tropical rainforests in Southeast Asia and New Guinea, was the result of domestication in *acuminata* subspecies that progressively stimulated female sterility and parthenocarpy, basic characteristics for selection and maintenance by humans (Perrier *et al.*, 2011). Inter-subspecific hybridization – triggered by human population movements – produced the many edible AA. Triploid AAA cultivars arose from these diploids, resulting in a wide range of AAA genotypes (Sharrock and Frison, 2004; Ploetz *et al.*, 2007). The most common origin of these polyploids is likely to be *2n* gametes of diploids where gametogenesis has been modified, sometimes through failure of one division of meiosis and generation of a restitution gamete with the same genetic constitution as the parent. The importance of *2n* gametes has been considered in wild diploid species and cultivated polyploid crops (Ortiz and Peloquin, 1992). For instance, the use of RFLP markers have shown that 'Cavendish' and 'Gros Michel' AAA bananas had a common AA diploid ancestor from the Indian Ocean Islands that was incorporated in the triploid cultivars through *2n* gametes, with both AA cultivars having a different genotype contributing to the third genome through the addition of a haploid gamete (Raboin *et al.*, 2005).

In most parts of South-East Asia, these triploids, which are more vigorous and have larger fruits, replaced the original AA diploids. However, in New Guinea AA diploids remain of agriculturally significance and a wide range of diversity is still cultivated (Sharrock and Frison, 2004).

Human interaction was also responsible for natural hybridizations between the edible AA and *M. balbisiana* with the formation of AB, AAB, and ABB hybrids as a result. The Indian sub-continent is considered to be a major center for hybridization of *acuminata* types with the indigenous *M. balbisiana* and the region is noted for its wide variety of AAB and ABB cultivars. The indigenous *M. balbisiana* is considered to be more drought and disease resistant than *M. acuminata*, and such characteristics are often found in cultivars containing a 'B' genome. Hybridization would have given rise to a wide range of edible banana types, some of which would have survived and been multiplied by clonal propagation (Price, 1995).

Practical Conclusion

The classification of bananas and plantains in groups and subgroups based on morphological grounds has proven to be of practical value and is robust. In the current absence

of a performing molecular differentiation technique, the morphological identification of plantain cultivars remains of utmost importance, since many cultivars are economically superior, both in terms of productivity and of market value. As a result, this work will focus on the morphotaxonomy of plantains.

The AAB Plantain subgroup

The plantains in general

AAB Plantain fruits are slender and very starchy. They are usually fried, roasted or boiled because they are unpalatable when raw, hence their common but rather misleading classification as cooking banana (Hahn *et al.*, 1990). They have an orange pulp unlike most other 'cooking' bananas, except the AAB subgroups Maia Maoli-Popo'ulu and Iholena in the Pacific (Bakry *et al.*, 2005).

The number of plantain cultivars grown in West and Central Africa was previously already estimated at about 100 or more (De Langhe, 1964b; Swennen, 1990; Swennen and Vuylsteke, 1987). Very few plantain cultivars have been reported in other continents, a fact which strongly indicates that the diversity was created by farmers in Africa, who must have vegetatively propagated somatic variants that were attractive for one or another reason. Outside Africa, one Horn plantain cultivar* is rather ubiquitous but very sparsely distributed. A very low diversity in French plantain was recorded in the state of Kerala in India (Simmonds, 1966). Only a couple of French plantain cultivars have been found in the Pinatubo Mountain region in the northern Philippines and throughout Indonesia (De Langhe and Valmayor, 1979). The plantains grown in Latin America originated from Africa, as a result of the slave trade. It is then not surprising that the 41 Latin American plantain cultivars described in the INIBAP Musalogue of Musa Germplasm Diversity are all from Africa (Daniells *et al.*, 2001).

The exact origin and route of plantains to and across the African continent are not fully known to date. It is assumed that plantains likely originated in the area in and around New Guinea (Carreel, 1994; Carreel *et al.*, 2002; De Langhe, 2009) but recent molecular findings tend to place the origin in the Philippines area (De Langhe *et al.*, 2015). Several theories have been advanced on their introduction into Africa. One of the more recent theories suggests that plantains were the first subgroup to reach the continent more than 2500 years ago, with Austronesian-speaking ancestors as possible vectors (De Langhe *et al.*, 1994-5; De Langhe et Marret, 1999). The discovery in Cameroon of phytoliths belonging to the plantain subgroup supports this suggestion. From these phytoliths one can assume that initial plantain cultivation would have progressed across the continent from East to West over a period of 3500-2500 BP (De Langhe, 2007; Mbidda *et al.*, 2001).

* For the distinction of the major Plantain types, see the subchapter "French, False Horn and Horn plantains"

Africa thus hosts two secondary centers of edible bananas, one for the AAB plantains (AAB) in West and Central Africa and one for the East African highland bananas (AAA-EA), with about 50 cultivars (De Langhe, 1969; Lescot, 2000).

Molecular genetics has confirmed that the wide spectrum of plantain cultivars make up a homogenous subgroup (i.e. derived from one or a very limited number of genetically similar basic AAB hybrids and siblings), which greatly diversified by accumulated somatic variation to give a complex reticulate pattern of variability (De Langhe, 1961a; 1964a). Characters of seemingly parental origin are pseudostem architecture and the mostly rather slender and slightly angular fruits (De Langhe, 1964a; 1964b). A large number of somatic variants have affected pseudostem color and dwarfism, fruit color, fruit shape and apex, and the inflorescence morphology (De Langhe, 1964a; Tezenas du Montcel *et al.*, 1983; chapters 3 and 4 this volume).

Plantain cultivation largely occurs in the rainforest zone. Indeed, plantains require a humid warm climate without major oscillations. The pseudostem suffers heavily from a long dry period and a dry season of more than three months is detrimental. The pseudostem will also die off after a few nights with a temperature of less than 10° C. The underground parts, the corm and the rooting system, eventually perish as well, contrary to many other bananas, such as in the hardy ABB group, where the corm survives to produce a new pseudostem after a long period of drought or cold. Plantains can survive under protected growing conditions at elevations between 1000 and 1600 masl. In these habitats, the plant develops slowly but suckers will grow better, apparently due to diminished apical dominance, so that survival is ensured. The environmental conditions for reasonable productivity severely restrict suitable areas for plantains in Africa (De Langhe, 2007). Consequently, plantains are currently rare on the highlands in East Africa and in savanna regions. In West and Central Africa, plantain is cultivated from Guinea to the DR Congo and the Central African Republic. The major producing countries, with annual output exceeding a million tons, are the, Ghana, Nigeria, Côte d'Ivoire and Cameroon. In these countries production of plantain ranks high among the starchy staples (Akyeampong, 1998).

Reported yields are as low as 5 t/ha in the DR Congo (Ba Kumfufutu, 1996), 6 t/ha in Ghana (Hemeng *et al.*, 1996), 10 t/ha in Central Africa Republic (Mbetid-Bessane, 1997) and 15 t/ha in Eastern Nigeria (Echibiri, 1996). On fertile volcanic soils in Cameroon, yields may reach 26 t/ha (Ngalani, 1996). The yields are low because of constraints such as diseases and pests, weeds, lodging/toppling/snapping (caused by weevils and nematodes), inherently low soil fertility, poor crop and soil management and the use of poor quality planting materials – infected by pests or diseases (Arene, 1996; Swennen *et al.*, 1988; Wilson *et al.*, 1987).

Smallholders traditionally choose to grow plantains as an intercrop within a shifting cultivation system. Experience has taught that highest returns are achieved when plantains are planted first on the field of newly burnt forests which is rich in organic matter and nutrients. Usually after two years plantain becomes unproductive and is planted elsewhere (De Langhe, 1967; Swennen, 1984; Wilson *et al.*, 1987).

Furthermore, nearly all plantain cultivars exhibit strong apical dominance (Swennen *et al.*, 1984), which is possibly the main cause for the yield decline starting less than two years after planting. This strong apical dominance is manifested by the existence of many buds, peepers and small sword suckers which fail to grow any further until after flower initiation and bunch maturation. Then these suckers soon form their own foliage leaves and become rather small maiden suckers competing with each other (Swennen *et al.*, 1984).

French, False Horn and Horn plantains

Plantains are commonly categorized into three types according to the degree of the so-called "inflorescence degeneration" (De Langhe, 1961a; Tezenas du Montcel *et al.*, 1983) (Fig 1.2):

- 'French' plantains, which develop a complete inflorescence, with the male bud being present at maturity;
- 'False Horn' plantains, which have a very reduced male inflorescence with the male bud disappearing long before maturity;
- 'Horn' plantains, without any flowers below the fruits.

It is demonstrated in Chapter 3 that the three types form a single subgroup, which implies mutations with deep morphological consequences.

Challenges of plantain productivity

Attempts to improve the productivity of plantain cultivation in West and Central Africa have always been confronted with the so-called "rapid yield decline syndrome". All cultivars, including French, False Horn or Horn plantains are susceptible to this

Figure 1.2. The three types in the plantain subgroup

behavior. In contrast, fields of most dessert bananas and the East African Highland bananas remain productive for many years, certainly when sufficient fertilizers and/or manure are applied. But fertilizer trials on plantains proved to be inefficient (Swennen *et al.*, 1984). The basic reason for the plantain yield decline is the plant's typical subsoil morphology, which includes poorly ramified roots, slow sucker growth, and a resulting "high mat" (i.e. the tendency of the plant base to grow out of the soil) (Swennen *et al.*, 1986). Indeed, it was found that the root system of most other banana varieties was more developed than that of plantain. Even under fertilized conditions, their root system was longer and denser than that of plantain. This different rooting pattern may have its consequences for the different suckering behavior. When mulched, the plantain root system developed significantly better. However, it was still inferior to the banana root system (Swennen *et al.*, 1984).

The plantain yield decline phenomenon is common in the forest area of the Tshopo district (Oriental Province of DR Congo), where all plantains disappear after three years of cultivation, unlike the AAA *Musa* and particularly the 'Yangambi Km 5' ('Ibota') cultivar. Several wild AA subspecies, introduced by De Langhe in the INEAC station of Yangambi in the 1950's still exist today without any maintenance (Joseph Adheka, person. comm.).

Since the 1980s, the black sigatoka disease (BSD) is generally considered to be the most serious constraint to plantain and banana production in sub-Saharan Africa. First identified in Fiji in 1964 (Rhodes, 1964), it is uncertain how the disease was introduced but it spread rapidly during the 1980s, first in Central and West Africa, and later in East Africa (Fouré 1985; Dabek and Waller, 1990; Blomme *et al.*, 2013). Because the spores of *M. fijiensis* are dispersed by wind, the expansion of the disease cannot be slowed down by plant quarantine measures alone. Once established, the pathogen causes severe leaf necrosis, reducing yields by 30-50% (Stover 1983; Mobambo *et al.*, 1993). All plantain cultivars are susceptible and this is due to their very narrow genetic basis as they have originated from the same ancestor, most probably via somatic mutation.

As it is impossible for the smallholder to control the disease with expensive fungicides, genetic improvement of plantains is the only solution. A most effective strategy would thus be to provide smallholder farmers with BSD-resistant plantain-derived hybrids developing a more vigorous rooting system and thus a better suckering (Vuylsteke *et al.*, 1993; Ortiz and Swennen, 2014).

Practical consequences of a correct classification of the plantain cultivars

The breeding of plantains had been initiated during the 1950s at Yangambi (DR Congo), and was resumed in recent decades by the International Institute of Tropical Agriculture (IITA) and the Centre Africain de Recherches sur Bananiers et Plantains (CARBAP), the previous 'Centre Régional sur Bananiers et Plantains' (CRBP). High yielding and BSD resistant hybrids have been produced (Swennen and Vuylsteke, 1993; Vuylsteke

et al., 1993a; 1993b) and released (Lemchi et *al.*, 2005; Faturoti *et al.*, 2006). But the spectrum of these hybrids is rather narrow because it started from a few cultivars. Many other cultivars with market potential and grown by the farmers but not yet duly classified, are awaiting such improvement. Consequently, the genetic improvement should be extended to more cultivars. It should thereby be underlined that consumer preferences vary from region to region within the Plantain belt.

However, breeding is hampered by the confused nomenclature of the plantain cultivars. Indeed, a single cultivar may have several different names according to the many languages spoken in its African zone of cultivation, a zone that includes more than 200 Bantu languages, the Southern-Sudanese languages in Northeast DR Congo, and languages of the Adamawa-Ubangi group. This synonymy problem is never adequately addressed, except in a few publications, which incidentally mentioned a couple of them. As a consequence, reported plantain hybrids can refer to a similar relatively fertile cultivar but under different names, dependent on the station/center where the breeding was performed. More in general, and because of synonymy, the name of a plantain cultivar in one institute has in most cases no meaning in other institutes and research/extension organizations in other places/countries.

The nomenclature obstacle can only be solved by systematic research on synonyms of all the plantain cultivars over the entire plantain belt in Africa. This is such a gigantic endeavor that it explains why this problem has not yet been solved. However, one can conceive that such task has to be undertaken in phases, starting from a few major institutes that occur within the plantain belt. The University of Kisangani (UNIKIS) is playing a pioneering role in this undertaking and the present work is a first basic step.

Conclusion

All plantain cultivars constitute a single *Musa* subgroup. However, the description of this subgroup is scantly documented in the literature, beyond the brief description by Simmonds (1966) who noted that plantains have a "compound tepal yellow-orange in color; male axis sometimes absent or, if present, sometimes clothed with persistent male bracts and flower relicts. Fruits are slender, angular-pointed, fleshy and starchy at ripeness, and unpalatable when raw". The lack of a satisfactory classification of the AAB Plantain subgroup leads to at least three negative consequences: (1) it is difficult, if not impossible, to rapidly compare accessions; (2) in describing the variation within the subgroup, any cultivar needs to be entirely described due to lack of a reference to the subgroup definition (which would show that many descriptors are identical in all cultivars); (3) any research on plantains, including genetic improvement, encounters the problem of heterogeneous nomenclature for each cultivar and renders information exchange impossible.

The procedure for reaching the desired classification is explained in detail in the three following chapters.

Characterization efforts of plantain cultivars in Africa

Past characterization efforts

Plantain characterization in DR Congo

The importance of plantain as a staple food in Congo was already recognized during the first decades of the 20th century. Between 1910 and 1925, the 'Bulletin Agricole du Congo Belge' published a series of agricultural surveys, carried out across the entire country by administrative officers. They revealed the exceptional diversity in plantain cultivars and the great care taken by the farmers to conserve any possible variant. Unfortunately, beyond the many recorded names, description of the cultivars was too sketchy for reliable identification. An exception is the study of plantains in the Mayumbe by the botanist J. De Briey (1920), with descriptions and drawings for each cultivar (but still with a Latin 'species' name, a common practice in the botanic literature at that time). The linguist and ethnologist Gustaaf Hulstaert spent his lifetime studying the very large Mongo ethnic group, and recorded more than 40 different plantain cultivar names (Hulstaert, 1957). But again, the short description per cultivar-name and the lack of illustrations do not allow a correct identification.

Research on *Musa* started in 1933 at the 'Institut National des Etudes Agronomiques au Congo' (INEAC) at the research center of Yangambi (Ishopo district, Oriental Province). The focus was on cultivar screening for higher productivity using cultivars grown by the tribes around Yangambi (Muller, 1947). The challenge was to deal with the different vegetative growth cycles of different cultivars varying from 6 to 15 months. In addition, that research was quickly confronted with the occurrence of duplicates bearing different names, as almost each tribe had its own naming for the same cultivar. Muller therefore systematically collected and characterized plantain cultivars in the 1940s to assess the synonymy in the Yangambi region. Muller's publication became a good reference for plantain cultivar characterization and classification during the 1950s. While the Yangambi collection eventually reached more than 50 different plantain accessions, region-specific collections were also established during the 1950s in the INEAC stations of Bambesa (Oriental Province), Mvuazi (Bas-Congo) and Mulungu (South Kivu). Plantains were mainly found in Oriental Province, while mainly Highland AAA cultivars were collected in South Kivu.

Unfortunately, and starting from the 1960s, social unrest, civil wars and political instability put this ample work on plantain characterization on halt for several decades and these early *Musa* collections progressively disappeared.

Still, the characterization-focused studies during the 1950s resulted in a series of breakthrough publications in international journals, especially for plantains (De Langhe, 1961a; 1961b; 1964a; 1964b; Dhed'a *et al.*, 2011b). For instance, the taxonomic study of 56 plantain cultivars collected and characterized by De Langhe (1961a) in Yangambi documented the three inflorescence types, "French", "False Horn", "Horn", and three plant sizes, 'giant', 'medium' and 'small'. The plant size was found also to be positively correlated with the number of hands per bunch produced, with time until harvest and number of leaves produced until flowering (De Langhe, 1964a).

Comparative studies conducted on the same *Musa* cultivars planted in both INEAC Yangambi and Mulungu (1470 masl) collections revealed that agro-ecological conditions affected the expression of some characters. It was for example found that the fruit orientation changed with the environment. Indeed, the bunch of some plantain cultivars, such as *Bosua*, had strictly erect fingers in the Yangambi collection, but these were a little less erect when the clone was transplanted in the Mulungu collection near Lake Kivu, and formed a less cylindrical bunch. Fruit orientation is probably controlled by growth substances such as auxins (Tezenas du Montcel *et al.*, 1983), but the mechanism remains unknown, although the erect position reflects negative geotropism and this seems to be affected by the environment. It was hypothesized that light quantity and quality might play a role (De Langhe, 1961a).

Plantain characterization elsewhere in Africa

Outside DR Congo, and up to the 1970s, work on plantains was limited to the maintenance of field collections in Côte d'Ivoire, Cameroon and Ghana. A remarkable exception was the taxonomic-linguistic research on plantains in Gabon by Walker (1931). His publication revealed the great plantain diversity in Gabon and his descriptions had a deep impact on the plantain taxonomic research in Yangambi. Unfortunately, these impressive results did not prompt the public administration to consolidate plantain research in Gabon.

The 'Centre de cooperation international en recherche agronomique pour le developpement' (CIRAD), formerly the 'Institut de Recherche sur les Fruits et Agrumes', had conducted studies on plantain in Côte d'Ivoire, Guinée and Cameroon in the 1970s and a plantain germplasm collection, as well as studies on intensive monocropping production, were initiated (Marchal and Mallessard, 1979).

Other research on plantains in West Africa started in the 1970s at both the IITA in Nigeria, and CARBAP in Cameroon. In both institutes, taxonomic research on plantains started by adopting the classification system developed in Yangambi (Swennen and Vuylsteke, 1987; Tezenas du Montcel, 1979; Tezenas du Montcel *et al.*, 1983; IITA, 1994).

IITA started to collect plantain germplasm in 1976, first in Nigeria and later in Ghana. As from 1979 collecting efforts increased drastically with more plantain varieties from Nigeria, Cameroon, Côte d'Ivoire, Gabon and Congo (Brazzaville). In 1979 the plantain field genebank was transferred from Ibadan to Onne, Nigeria which contained 47 varieties (Swennen, 1990). Swennen (1990) suggested that more than 100 plantain cultivars could possibly exist in West Africa but Swennen and Vuylsteke (1987) did not find 17 cultivars that were described earlier in Congo. Yet, in the Onne field genebank, 26 cultivars had a short habit (small, semi dwarf or dwarf). Interpretation of the determination key of the 56 DR Congo plantain cultivars (De Langhe, 1961a) suggest that among the plantains present in Onne, 32 cultivars were in common with the ones from Yangambi. Among the plantains at Onne, 25 cultivars were studied in detail as they were believed to represent the major variability of the plantain subgroup in West Africa (Swennen and Vuylsteke, 1987). These plantains had been introduced from Ghana, Côte d'Ivoire, Nigeria and Cameroon but the authors also found them in other African countries, yet under different names. The *Musa* field collection at IITA did not include accessions from DR Congo (Swennen, 1990). Approximately 30 characteristics were studied. Many characteristics showed no variation between entries, and a tentative description of plantain in West Africa was produced. As in Yangambi, variations were found mainly in the bunch-type (French, False Horn and Horn), plant size (giant, medium and small), bunch and fruit orientation, fruit apex shape and fruit curvature (Swennen and Vuylsteke, 1987).

The CRBP (Centre de Recherches sur les Bananiers et Plantains), was established at Nyombé (Cameroon) by a convention signed in 1989 between the Ministry of Scientific Research and Technology (MINREST) of the Republic of Cameroon and CIRAD. The Centre has later been reorganized and is currently called CARBAP (Centre Africain de Recherches sur Bananiers et Plantains). CRBP-CARBAP is mandated to improve the production of plantains and other locally consumed bananas to meet the needs of a growing population, through the development of a sustainable and environmentally friendly agriculture. In order to achieve the aim, it has the triple responsibility of research, development and training (INIBAP, 2001). Research activities include germplasm collection and studies on pest and disease control, plantain diversity, physiology and cropping intensification (Lescot and Ganry, 2010).

Linguistic-botanic studies of plantain

The two important collections of IITA and CARBAP probably represent the large majority of plantain cultivars in West Africa. Many of the accessions likely correspond with cultivars in DR Congo. However, the West African accessions have vernacular names that widely differ from the ones recorded at the DR Congo collections, and no comparative synonymy study has been carried out to detect overlap. To meet this shortcoming, INIBAP (International Network for the Improvement of Bananas and Plan-

tains) launched a linguistic study in the early 1990s. Various reports were consulted and many countries were visited, which resulted in the collection of hundreds of vernacular names of plantain cultivars (Rossel, 1998). Unfortunately, the actual objective – synonymy assessment – was not met, due to lack of sufficient cultivar descriptions, as the descriptors were limited to bunch morphology and orientation, pseudostem size and color, and fruit shape. When the INIBAP Director Edmond De Langhe left his function in 1992, no follow-up was organized.

Plantain taxonomy at UNIKIS

Historical review

With the disappearance of the large field collection at Yangambi, the need for an alternative collection in DR Congo became necessary. Indeed, many of the 56 plantain cultivars collected during the 1950s in the eastern Congo Basin (DR Congo, and more particularly in the Tshopo District, Oriental Province, does not seem to be present at CARBAP, Cameroon, where 44 cultivars had been collected (De Langhe, 1961a, Tezenas du Montcel *et al.*, 1983). Even the IITA collection in Nigeria which included, among others, plantain cultivars introduced from Nigeria, Ghana, Côte d'Ivoire, Cameroon, Gabon and Congo Brazzaville did not include plantain cultivars from DR Congo (Swennen, 1990). Consequently, it became important to (re)collect DR Congo plantains and to (re)introduce them in a field collection at UNIKIS. This has been achieved in the framework of four successive projects that constitute a single undertaking from a taxonomical perspective

Project 1

In 2004, the Gatsby Charitable Foundation funded a UNIKIS Bioversity International-led project on 'Plantain in the Eastern Congo Basin'. The objectives were (i) to (re) collect in the Oriental Province part of the unique set of plantain cultivars, (ii) to establish and maintain these cultivars in a field collection at UNIKIS, (iii) to duplicate the collection *in vitro*, and (iv) to back up this plantain material at the International Transit Centre (ITC), Leuven, Belgium for sub-equent virus indexing/cleaning. From January 2005 to May 2007, four collecting missions were carried out by UNIKIS to cover the plantain diversity in part of the Oriental Province (Tshopo – around Kisangani and Yangambi; Ituri – around Kilo, close to the border with Uganda; Haut Uele – around Wamba, close to the border with Sudan; and Bas Uele – close to the border with the Central African Republic) and to recover cultivars of the extinct plantain collection of INEAC, Yangambi (Dhed'a *et al.*, 2011b).

A total of 65 plantain cultivars was collected, the majority being of the medium plant size (64.6%), followed by giant size (20%), dwarfs (12.3%) and semi-dwarfs (3.1%). Six putative new plantain cultivars were found in the Bas Uele district. These plantain

cultivars, which looked different from those observed in the Tshopo and Ituri districts, were the giant French *Mogele*, the medium French *Ongua*, the dwarf False Horn *Ngonde* and *Sika* presenting black streaks on the peel (Dhed'a *et al.*, 2010b).

Project 2

The effort on plantain characterization studies continued in 2009 by the UNIKIS with support from the Consortium for Improving Agriculture-based Livelihoods in Central Africa (CIALCA) and the Flemish Inter-University Council, Belgium (VLIR). From February to October 2009, *Musa* germplasm surveys were held in respectively 24 villages and 240 households in the surroundings of Kisangani town and seven territories of Tshopo district in DR Congo (Dhed'a *et al.*, 2011b).

A total of 47 plantain cultivars (26 French, 14 False Horn and 6 Horn) were recorded in the Tshopo district. Although French plantains were the most numerous, they represented only 11% of mats in the farms. False Horn plantains were the most widespread on farm with 76% of mats. Horn plantains were ranked second with 13% of mats on farm.

Project 3

From 2010 to 2012, plantain germplasm surveys were carried out in eleven territories in Oriental Province, five in Katanga, Eastern Kasai, Western Kasai and Bandundu provinces, respectively, six in Maniema and fourteen in Equateur. Surveys were carried out in 189 villages and 1890 households whereas the objectives of the surveys in this project were (i) to identify the maximum of banana and plantain cultivars in the Congo basin in DR Congo and to identify those which were widely grown and known by farmers; (ii) to assess criteria used by farmers for selecting banana and plantain cultivars; and (iii) to define the farmers' preference for the different cultivars and their main uses.

Initial survey results indicate that plantain cultivation and diversity were low in the savannah zones of southern Kasai or Katanga. Indeed, plantain is more widely grown in the hot and humid climates of the lowland regions at 0–750 masl. The plantain cultivars *Libanga likale*, *Libanga litimbo*, *Litete*, *Ikpolo* and *Ikpolo red* dominate the plantain landscape, showing that False Horn and Horn clone sets are the most common across the surveyed DR Congo provinces. In accordance with past observations (Adheka, 2010, Dhed'a *et al.*, 2011b), the predominance of False Horn and Horn plantains can be explained by their short cycle and high market demand.

Project 4

Plantain cultivars collected in projects 1 and 2 were established in a field collection of ¼ ha located in the faculty of sciences of UNIKIS at Kisangani, DR Congo. With the great number of putative new cultivars collected in 'project 3', the first field collection had become insufficient for containing all the collected UNIKIS accessions. As a result,

a compound project of sustainable agriculture, including an important characterization aspect started in UNIKIS with support of VLIR-UOS, and with the aims to (1) recollect cultivars which were installed in the previous collection but which were lost afterwards; (2) extend the field collection and (3) maintain the accessions established in the collection under optimum growth conditions.

Two recollection missions were conducted respectively in Bas Uele district (Oriental Province) and Equateur province. In total, 11 plantain cultivars were recollected. The new field collection has an area of 1 ha that is split into three blocks. Each accession is represented by at least 10 plants in a single row, with a spacing of 3 × 3 m within and between rows. As in the previous collection, when planted and subsequently twice a year, approximately 30 kg pig dung is applied to restore soil fertility. In order to maintain soil fertility, twice a year *Vigna esculata* is planted on the entire field whereas *Albisia spp.* and *Acacia spp.* are mulched in the field. In addition, a hedgerow of *Pennisetum purpureum* (for mulching) is installed between blocs. The new collection represents already 83 different cultivars. Other cultivars are under observation for definitive confirmation as new accessions.

General outlooks on UNIKIS plantain taxonomy project

The recent results from UNIKIS investigations were in agreement with the previous INEAC studies concerning pseudostem color and the fruit peel color. However, new characteristics were found such as the dark green pseudostem color and fruit peel in False Horn and yellow fruit color in giant French plantains, showing that more plantain cultivars could be identified in the Congo Basin. In-depth characterization and synonymy verification are needed to pinpoint similar cultivars across ethnic group boundaries.

Description of the AAB Plantain subgroup

An exhaustive description of a cultivar is not sufficient to identify its place in the edible *Musa* germplasm. It should not only be classified in one of the groups AA, AAA, etc., but also in a particular subgroup.

This chapter addresses two shortages that hampered such a complete and reliable identification of plantain cultivars: an unequivocal definition of the AAB Plantain subgroup, and a demonstration that the plantain types French, False Horn and Horn all belong to the plantain subgroup.

The three AAB Plantain types, French, Horn and False Horn form one single subgroup

The partial or the complete absence of flowers below the fruits in False Horns and Horns makes the use of a large number of floral descriptors impossible, yet flowers are necessary as part of a subgroup description and classification. Lack of the description of flowers, could open speculation that False Horns and Horns may belong to one or more different subgroups. We demonstrate by different means that the three plantain types belong indeed to the same AAB Plantain subgroup.

Significant descriptors

Female flowers are the only part of the inflorescence which can be compared amongst French, False Horn and Horn plantains. They consist, as in any other *Musa* taxa, of a long gynoecium, a compound 5-membered tepal surrounding the thick style, a sixth ('free') tepal, and five or six non-functional stamens (De Langhe, 1969).

The three plantain types at a same early flowering stage in the UNIKIS collection exhibit female flowers consisting of a cream compound tepal (with no pigmentation) but with a pink rim at the base, and a bright yellow developed lobe (Figure 3.1). The free tepal, a simple folding under the apex with a rounded shade, has a translucent white color. The apex of that free tepal is thread-like and presents little or no visible signs of development. The basic color of the style, which has a straight shape, is cream without pigmentation.

Figure 3.1. Female flowers of the three plantain types.

Therefore, French, False Horn and Horn plantain female flowers show the same characters at the same early flowering stage. As a result, all flowers of False Horns and Horns might have the same characteristics as French plantains even if they would develop a complete inflorescence.

Confirmation via in vitro somaclonal variation

In a large experiment involving many plantain cultivars, somaclonal variation induced by rapid *in vitro* propagation affected many characteristics (Vuylsteke *et al.*, 1990). The level of somaclonal variation ranged from 0.3% to 69%, depending on the cultivar. For example, the cultivar Big Ebanga and Agbagba, which have a similar phenotype except that the former is giant in size while the latter is medium sized, showed similar inflorescence variations, but with a tenfold difference in the extent of this variation (34% and 5%, respectively) (Vuylsteke *et al.*, 1990).

Among the somaclonal variants of the plantain cultivar Agbagba, a False Horn plantain widely cultivated under different names in West Africa (Swennen, 1990; Swennen and Vuylsteke, 1987), two inflorescence-type variants closely resembled other existing plantain cultivars. They were designated 'French reversion' and 'Monganga'-type. The former variant produced an inflorescence typical of the French plantain, having a complete inflorescence with several, relatively small fruits, many persistent intermediate flowers, and a male bud present at maturity (Tezenas du Montcel *et al.*, 1983; Vuylsteke *et al.*, 1988). The 'Monganga'-type variant produced a False Horn inflorescence with a much shorter male rachis resembling the cultivar Monganga of the Yangambi collection in the 1950s (De Langhe, 1961a; Vuylsteke *et al.*, 1996).

The bulk of the inflorescence variation mimics the observed *in situ* variability and should thus not be considered as being generated by *in vitro* culture per se. The frequency of the variation is however considerably amplified *in vitro* (Vuylsteke *et al.*, 1988).

The stability of the *in vitro* obtained variants in their ratoons and among sucker progeny (following a cycle of conventional clonal propagation) suggests that the variation is not a transient phenotypical phenomenon but of genetic or epigenetic origin. The evaluation of Agbagba variants following conventional propagation after another *in vitro*

passage, i.e. by reintroducting off-types from the field to *in vitro* culture showed that the French reversion variant of *Agbagba* was stable among sucker progeny (72 plants) and *in vitro* progeny (197 plants) (Vuylsteke *et al.*, 1990).

Indications in the field

In the rainforest region – apparently the most suitable habitat for plantains – French plantain cultivars are most numerous. In the UNIKIS collection for example, the proportion of French cultivars (66.7%) is higher than the proportion of False Horn (23.3%) and Horn (10%) plantains (Dhed'a *et al.*, 2011b; Chapter 2, section 2.2.2.3 Results). This gradual decrease in numbers could indicate that French plantains were the first plantains, of which part of them underwent variation to the False Horn form and finally, again a part underwent variation to the Horn form. This trend of the high number of French plantains over other plantain types (i.e. False Horn and Horn plantain) was also observed in other collections in humid Africa. From the 56 plantain accessions collected by De Langhe mainly in Oriental Province during the 1950s and established in the Yangambi collection, 34 were French plantains while only 13 and 9 were False Horn and Horn plantains, respectively (De Langhe, 1964a).

The large abundance of French plantains was also observed on-farm. On-farm surveys conducted in the Tshopo district (Oriental Province, DR Congo), revealed that French plantains were the most numerous with 26 cultivars, followed by False Horn (13 cultivars) and Horn (6 cultivars) plantains (Adheka, 2010; Chapter 2, section '2.2.3.3 Results'). The results of two surveys conducted in Southern Cameroon in 1999 and in 2001 show that among 32 cultivars reported, 18 were classified as French plantains, 7 as False Horn plantains and 6 as Horn plantains. However, in that study, there was a risk that due to language differences a same cultivar could have been quoted more than once (Hauser and Amougou, 2010).

Possible origin of the three plantain types

In situ studies held in Yangambi and Mulungu collections (DR Congo) allowed the reconstruction of six successive phases in the male inflorescence degeneration phenomenon (Table 3.1; De Langhe, 1964b).

Phase 1 is common to the edible banana subgroups. Phases 2 and 3 can be observed in several subgroups. Phase 4 is restricted to the AAB Plantain and AAB Maoli-Popo'ulu subgroups and – remarkably – a number of edible AA cultivars in New Guinea. Phases 5 and 6 seem exclusive to AAB Plantain.

The edible AA cultivars in New Guinea as well as the AAB Plantain and AAB Maoli-Popo'ulu subgroups are considered to be the oldest edible bananas, of which the basic hybrids may have been formed 3,000-5,000 years ago (Perrier *et al.*, 2011). It can thus be assumed that a morphogenetic degeneration process affected the inflorescence of plantains over an extremely long period of clonal propagation with progressive in-

Table 3.1. Postulated phases in the male inflorescence degeneration

Phase	Characteristics
1	Basal male flowers experiencing an 'ovary' hypertrophy and are commonly called 'neutral' flowers
2	Male flowers (especially the basal flowers) remain attached to the floral axis
3	Total number of hands and flowers decreases; terminal part however still exists at the maturity
4	Male bud more or less quickly exhausted before maturity, trend towards large fruits
5	No trace of male flowers; the last female hands also disappear, some cultivars produce only one hand or even one large fruit
6	Floral axis no longer carries fruits; two or three very thick but very narrow bracts hang to the empty crowns

creases in sterility, hence without any regeneration by seedlings that could otherwise have restored the original inflorescence morphology. The degeneration hypothesis implies that False Horn and Horn types may well have derived from a single basic hybrid resembling the current French type with its complete inflorescence. Molecular genotyping confirms this concept since it has as yet not been able to differentiate the three types, hence suggesting that this variation is of epigenetic origin. The epigenetic approach could explain why the current French type cultivars underwent no degeneration; a rather at random repression of the floral gene expression left the changes for many French clonal lines to subsist (see more in Chapter 5 sub 'Genetic significance of the plantain diversity').

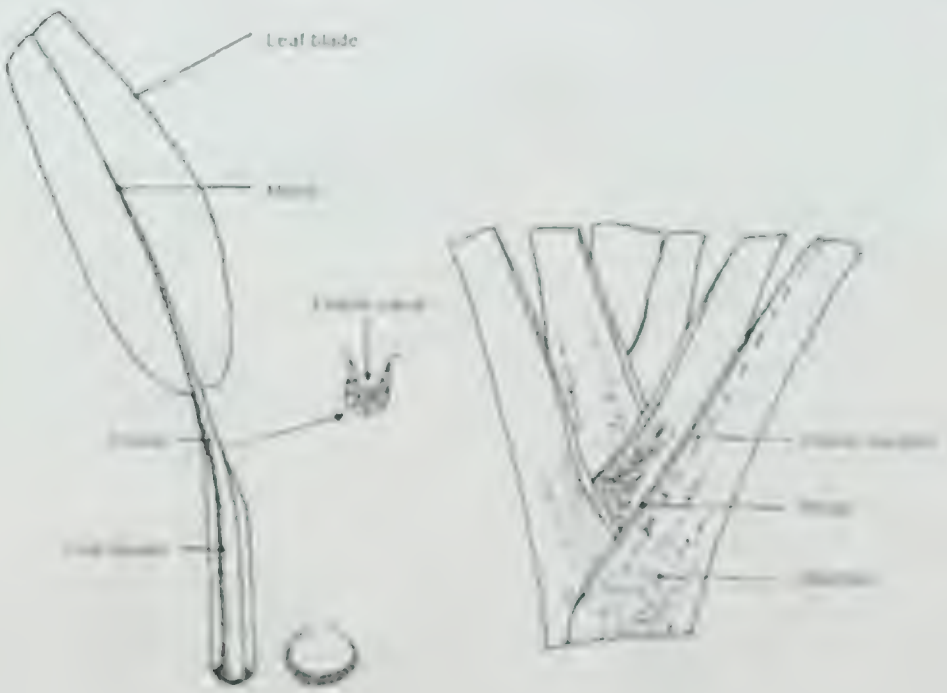


Figure 3.2. Example of drawings in the IPGRI Descriptors List for bananas. [Petiole/midrib/leaf (from Champion, 1963 (left); De Langhe, 1961a (right).]

The description of the AAB Plantain subgroup

Morphological and genetic evidence suggests that the three Plantain types French, False Horn and Horn belong to a same subgroup. As a result, this provides the opportunity to describe the entire Plantain subgroup by using the French type, since it develops a complete inflorescence. However, given the extraordinary inter-cultivar variation a rigorous verification of the similarity amongst cultivars is required before moving with confidence to a subgroup description.

The method followed here may serve as a pioneering example to establish subgroup descriptions in general. In brief, it consists of (1) a complete description of each collected cultivar, followed by (2) comparative analysis and extraction of the non-variable descriptors, which are considered to be specific to the subgroup of AAB plantains and (3) the addition of stable floral descriptors as observed in the French type.

Individual plantain cultivar descriptions

Musa taxonomists now commonly use a system developed by the International Plant Genetic Resources Institute (IPGRI) entitled 'Descriptors for bananas (*Musa* spp.)' for the identification and conservation of *Musa* germplasm in collections (IPGRI-INIBAP/CIRAD, 1996).

These descriptors are generally unequivocal, visually recognizable and assumed to be rather equally expressed in all environments. For each descriptor, its different forms are spelled out, with drawings for difficult cases, as illustrated in Figure 3.2. Observations should be ideally made in a field collection under optimal growth conditions.

The entire description consists of a list of 117 extended descriptors which are gathered in seven main sections: 'General plant appearance', 'Pseudostem Suckers', 'Petiole/Midrib/Leaf', 'Inflorescence Male bud', 'Bract', 'Male Flower' and 'Fruit'.

A set of 55 different plantain accessions in the UNIKIS field gene bank (Table 3.2), representing most of the plantain diversity in the Oriental Province was described by using the IPGRI-INIBAP/CIRAD Descriptor List (Annex 1, online available as 'doi')

Common and variable descriptors

Based on the descriptions of the 55 accessions-set (Annex 1, online available as 'doi'), 77 out of the 117 descriptors were recorded as non-variable across all the UNIKIS plantain accessions, i.e. common to all the described cultivars (Annex 2). In the list of non-variable descriptors, the 'Compound tepal basic color' (descriptor 6.6.2) and the 'Ovary basic color' (descriptor 6.6.22) must be considered with more attention. The tepal basic color in all plantain accessions is generally cream with a pink rim at its base. In some accessions however, orange streaks are observed on the tepal, while the basic color remains yellow (Figure 3.1). The common basic ovary color in plantain is cream. Some plantain accessions with red-purple ovary were observed (Figure 3.3)

Table 3.2. UNIKIS cultivars used for description of the AAB Plantain subgroup [*Names used in the analysis are put between brackets.*]

	French Plantains		
1	Adili	19	Gbegbele [Gwekwele]
2	Afati [Lokoka]	20	Ifel(Eng)Ete
3	Afati Noir [Afati Black]	21	Kamboloso
4	Akondje [Andula]	22	Libanga Libokoikoy I [Libanga Liboelabokoi]
5	Akpasi	23	Libanga Libokoikoy II [Libanga Liboelabokoi Red]
6	Aleke	24	Litete
7	Amagaba	25	Magoma I
8	Amakake	26	Magoma II
9	Amakoko III [Inekeleikumi]	27	Manimani [Tala]
10	Amungu	28	Mongele
11	Bolomaise	29	Nguku
12	Boofo	30	Ongua
13	Boofo Noir [Boosa]	31	Plantain Rouge I [Afati Red Wine]
14	Bosakaraka I	32	Plantain Rouge II [Yelola]
15	Bosakaraka II	33	Sika
16	Bosua	34	Yumba
17	Chwachwa	35	Yumba Noir [Yumba Black]
18	Egbe-O-Mabese II		
	False Horn Plantains		
36	Akoto	42	Libanga Lifombo
37	Ambulu Multiple [Libanga Multiple]	43	Libanga Likale
38	Apoka	44	Libanga Vert Sombre [Libanga Dark Green]
39	Apoka Magbuke	45	Libanga Noir [Libanga Black]
40	Bokpeta	46	Lingu
41	Egbe O Mabese I	47	Nembundu
	Horn Plantains		
48	Ifelete [Nselenge]	52	Lokusu
49	Ikpolo	53	Lokusu Rouge [Lokusu Red]
50	Ikpolo Noir [Ikpolo Black]	54	Moikili
51	Ikpolo Rouge [Ikpolo Red]	55	Tala Lola

Figure 3.3. The basic tepal and basic ovary colors in plantain subgroup. Note the orange streaks in the cultivar at the left.

The morphological study of plantain accessions in the UNIKIS collection showed that the basic ovary color (in the case of a color other than the typical basic cream ovary) is closely related to the fruit color. Consequently, the descriptor 6.6.22 will be considered as non-variable despite a few exceptions [considered in the descriptor 6.7.12 'Immature fruit peel color'].

The large majority of common descriptors across the set (77 117) sufficiently prove that all cultivars share a common basic morphology, typical for the AAB Plantain subgroup.

The additional French type floral descriptors

The descriptors given in Table 3.3 are only observable on the French types but do not vary among the cultivars of the type.

The complete AAB Plantain subgroup description

The subgroup description of the plantains can be achieved with confidence by using the non-variable descriptors plus the remaining floral descriptors of the French types.

The AAB Plantain subgroup is thus characterized as follows:

- *Pseudostem* of dull appearance, moderately waxy on leaf sheaths, suckers developed between ¼ and ½ of the height of the parent plant and close to parent, with watery sap.
- *Foliage*: leaf petiole canal with margins curved inward, winged and clasping the pseudostem, wings are dry, petiole margin color is green, its edge with a color line along, its margin width < 1 cm, leaf upper surface shiny, lower surface dull, leaves moderately waxy, the insertion point of the leaf blades on the petiole is symmetric, both sides

Table 3.3 Additional floral descriptors for complete subgroup description.

Descriptor	Status
• **6.4 Inflorescence / male bud**	
6.4.5 Peduncle hairiness	Slightly hairy
6.4.9 Flowers that form the fruit	Female
6.4.13 Rachis appearance	Neutral/male flowers and presence of withered bracts
6.4.15 Male bud shape	Intermediaire
6.4.16 Male bud size [cm]	21 to 30 cm
• **6.5 Bract**	
6.5.1 Bract base shape	Medium
6.5.2 Bract apex shape	Obtuse and split
6.5.3 Bract imbrications	Young bracts greatly overlap
6.5.10 Male bract shape	0.28 < x/y <0.30
6.5.11 Male bract lifting	Lifting one at a time
6.5.12 Bract behaviour before falling	Revolute (rolling)
• **6.6 Male flower**	
6.6.1 Male flower behavior	Neutral/male flowers persistent
6.6.2 Compound tepal basic color	Cream + pink rim at base
6.6.3 Compound tepal pigmentation	Very few or no visible sign of pigmentation
6.6.4 Lobe color of compound tepal	Bright yellow
6.6.5 Lobe development of compound tepal	Developed
6.6.6 Free tepal color	Translucent white
6.6.7 Free tepal shape	Rounded
6.6.8 Free tepal appearance	Simple folding under apex
6.6.9 Free tepal apex development	Little or no visible sign of development
6.6.10 Free tepal apex shape	Thread-like
6.6.11 Anther exsertion	Exserted
6.6.12 Filament color	White
6.6.13 Anther color	Yellow
6.6.14 Pollen sac color	Cream
6.6.15 Pollen vitality [%]	Absent
6.6.16 Style basic color	Cream
6.6.17 Pigmentation on style	Without pigmentation
6.6.18 Style exsertion	Same level
6.6.19 - Style shape	Straight
6.6.20 Stigma color	Yellow
6.6.21 Ovary shape	Straight
6.6.22 Ovary basic color	White
6.6.23 Ovary pigmentation	Very few or no visible sign of pigmentation
6.6.24 Dominant color of male flower	Cream
6.6.25 Irregular flowers	Absent
6.6.26 Arrangement of ovules	Four-rowed (more or less)

of the leaf blade base are rounded, leaf corrugation weak (few stripes), leaves of the water suckers with large purple blotches.

- *Inflorescence*: peduncle slightly hairy, flowers that form the fruit are female, rachis bears neutral male flowers and withered bracts, the male bud shape is intermediate; bract base shape medium, apex obtuse and split, pronounced imbrication (the young bracts greatly overlap), very waxy, moderate grooves, external face pink-purple without discolored line, internal face red without color-fading of the base, bract scars on the rachis very prominent, male bract shape = $0.28<x/y<0.30$, male bracts lift two or more at a time, bract revolute (rolling) before falling.
- *Male flowers*: compound tepal basic color is cream with a pink rim at the base, other pigmentation very weak or not visible, lobes bright yellow; free tepal translucent white, shape rounded, with simple folding under apex, apex a little developed with thread-like shape; anther exserted, filament white, anther yellow, pollen sac yellow, pollen vitality absent; style basic color is cream without pigmentation, stigma-top at same level with the lobes on the compound tepal, style shape straight, stigma yellow, ovary shape straight; ovary basic color is white, with very few or no visible sign of pigmentation; dominant color of male flower is cream, irregular flowers occur, especially in False Horn and Horn types; arrangement of ovules is four-rowed (more or less).
- *Fruit*: transverse section shows pronounced ridges, pedicel surface hairless, fusion of pedicels very partial or no visible sign, fruits do not peel easily (adherence of fruit peel), fruits persistent (fruits do not fall from hands at maturity), flesh texture firm, predominant taste mild, slightly tasty or tasteless, presence of seed with source of pollen = 5.

Testing the performance of the AAB Plantain subgroup description

The description should allow for unequivocal discrimination of the AAB Plantain subgroup from other AAB subgroups. Unfortunately, no such complete description has as been published so far for other subgroups. Especially one AAB subgroup, the Maoli-Popo'ulu in the Pacific presents possible confusion because they look at first sight quite similar to the plantain subgroup, particularly their vegetative parts. The considerable geographic distance is thereby not a good indication to infer differences, since both presumed subgroups may have originated in the same region and were possibly separated due to different human movements from that area to respectively the Pacific and Africa.

Fortunately, a rather complete description of the AAB Maoli-Popo'ulu subgroup could be extracted and constructed from a richly documented book dealing with the cultivars in Hawaii (Kepler and Rust, 2011). Thus a comparative analysis could be made and is presented in Annex 3. According to the table in Annex 3, both subgroups differ in 33 cases, of which those of the inflorescence largely dominate (27).

This attempt is based on only the Hawaiian part of the Maoli-Popo'ulu diversity in the Pacific and several descriptors may have been wrongly interpreted for Maoli-Popo'ulu. Nevertheless, the risk of confusion seems to be minimal to non-existent.

*Classification of the plantain diversity of the UNIKIS collection**

Because all the plantain accessions at the UNIKIS collection share the same characteristics of the subgroup, the study of the diversity is now focused on the variable descriptors as listed on the table in Annex 2. While the table is based on the 55 different cultivars initially collected, the more than 40 subsequent collected accessions provide some additional variation, but did not influence the subgroup description.

Coping with the limits of the list of *Musa* descriptors

It appeared that the total variation among the collected plantain cultivars strongly exceeds the scope of the guide 'Descriptors for bananas (*Musa* spp.)' (IPGRI-INIBAP CIRAD, 1996). A number of plantain cultivar characteristics called for 'new' descriptors or for a modification of some descriptors. Such kind of additional variation is probably typical for any large subgroup, but its content might change with the subgroup. Thus an adapted cultivar descriptor list per subgroup is preferable instead of a complicated extension of the current descriptor list.

According to the degree of differentiating performance and or economic value, the following descriptors are ranked by importance: (1) main descriptors, (2) secondary descriptors, and (3) rare descriptors. This approach makes the cultivar description logic and faster because it moves from general to specific characteristics, thereby progressively reducing the number of descriptors that are considered per cultivar.

Main descriptors

Main descriptors are quantitative and have therefore an economic importance.

- *Normal pseudostem size*

A 'Normal' pseudostem size is distinct from dwarf variants. The INIBAP IPGRI method expresses the size as the height in meters from the base of the pseudostem to the emerging point of the peduncle. However it is well known that the size of a cultivar (i.e.

* A note on terminology: the term 'accession' is used for precise reference to accessions of the UNIKIS collection, while the term 'cultivar' designs the corresponding specimen found at farm level

both height and circumference of the pseudostem) is closely linked to the growing conditions and growing cycle. For instance, when *Musa* cultivars are grown under shade, they tend to etiolate, thereby becoming relatively taller but with a more narrow pseudostem. Thus, the plant size in absolute figures (for example ≤2; 2.1 to 2.9; ≥3m) is only of value in a collection where cultivars are grown under similar conditions (Tezenas du Montcel *et al.*, 1983). But even then, the absolute size differs from one collection to another because of different environmental and field management conditions.

A much more reliable method for determining the size of a cultivar can be found in the number of foliage leaves produced from planting to flowering (De Langhe, 1964a). In practice, the number of remaining foliage leaves at flowering is counted plus all the scars of the leaf sheaths. In a collection, leaf scars can be tagged to facilitate counting. The result reflects the biomass of the pseudostem. De Langhe (1964a) could thus distinguish, at the Yangambi (DR Congo) *Musa* field station, between 'giant', 'medium' and 'small' plant sizes (see Table 4.1 for the French type). The correlation between the pseudostem and the bunch size is less clear in the False Horn and Horn type, because these types produce bunches with few hands but very large fingers.

The names of corresponding cultivars belonging to each plant size class are given in Table 4.2, for respectively French, False Horn and Horn plantain accessions.

- *Dwarfism*

We stress that 'Dwarf' is completely different from 'Small'. Although dwarf plantain cultivars have a small size, the dwarfs of the giant lineage for example produce more than 38 functional leaves before flowering similar to normal giants. As such, their plant circumference is as large as with giants. Dwarfism occurs also in other subgroups, with the Dwarf Cavendish as a well-known example. Consequently, dwarfism cannot be described by a simple measure of pseudostem height, but several morphological characters are tied to the phenomenon. As a result, a dwarf stature is best characterized by the leaf ratio 'Length/Width' of the limb, which is 1.8 for the dwarf Tala Lola, in contrast with the ration 2.8 ('Ikpolo') for normal sized cultivars. Moreover, dwarf plantain cultivars have a rather erect leaf habit and their false internodes are short and tightly packed.

Table 4.1. Normal plantain size categories.

	Giant	Medium	Small
Number of foliage leaves	≥ 38	32 - 38	≤32
Hands per bunch	≥9	6 - 8	≤5
Fingers per hand	>14	≤14	≤14
Duration between planting and maturation of the first cycle, in months	≥16	11 - 15	7 - 10

- *Semi-dwarfism*

This is a moderate degree of dwarfism. Semi-dwarfs are characterized by the criteria used for dwarfs but expressed to a lesser degree, i.e. intermediate between normal and dwarf. Observations on 56 plantain accessions in Yangambi led to the description of eight semi-dwarfs. These cultivars have a sub-horizontal bunch with rather short fingers (De Langhe, 1964a).

Thus, considering the dwarfism criterion, plantain cultivars are classified into three categories: 'Normal', 'Semi-dwarf' and 'Dwarf'.

- *Bunch orientation*

A single cultivar may present several types of bunch orientations as influenced by ecological factors and field management conditions; but the variation found between several cultivars grown under the same conditions can only be explained by causes inherent to the plant. In the plantain subgroup, the bunch can be pendulous (or nearly so), sub-horizontal, horizontal or even erect (Figure 4.1). Bunch orientation has an economical value because pendulous bunches have an almost cylindrical shape, which is convenient for transportation to the market.

However, the vast majority of the French plantains have a pendulous or nearly pendulous bunch while the majority of the False Horn plantains bear a subhorizontal bunch at immature state, becoming nearly pendulous at maturity. The Horn plantains have either a horizontal to erect bunch or a pendulous one. Given such variable bunch orientation, a general division of the plantain diversity across the three types has no added value, and the bunch orientation should be specified per cultivar.

Secondary descriptors

- *Pseudostem color*

The pseudostem color is green, dark green, red, and violet (Figure 4.2) with different shades of the colors as noticed in several other subgroups. However, the plantain subgroup displays also 'green' red' (mostly at the petiole margins), olive green, deep green, and even a combination of violet and red (De Langhe, 1964a).

- *The immature fruit peel color*

The immature fruit peel color can be green, dark green, red, yellow, but also with different shades (Figure 4.3).

- *Bunch density*

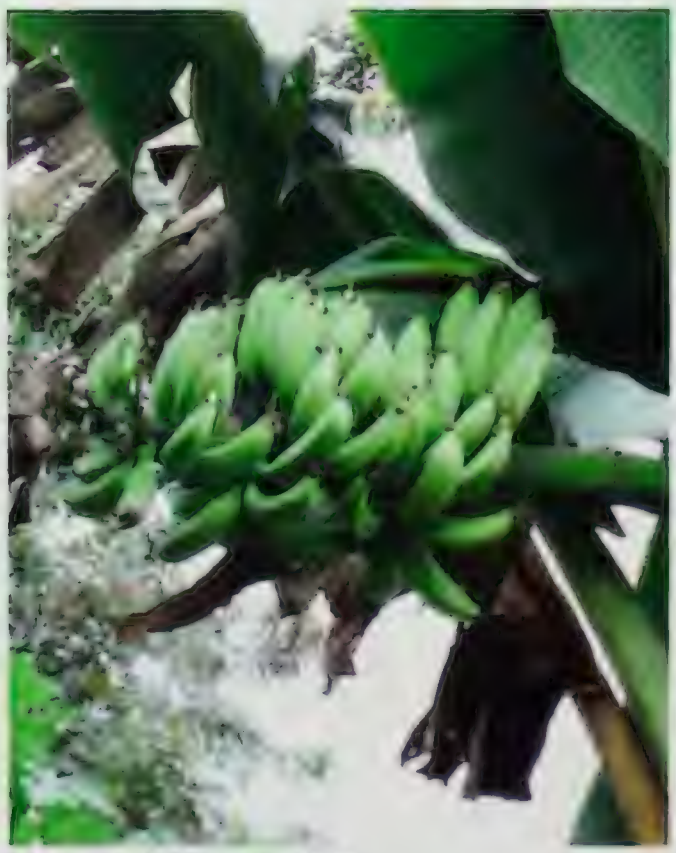
The bunch can be very compact, compact or lax (Figure 4.4).

- *Fruit shape*

The fruit shape can be straight, straight at the distal part, curved or curved in an 'S' as shown in Figure 4.5.

Pendulous: Lokoka

Sub-horizontal: Bakpala



Horizontal: Mumuisgbia

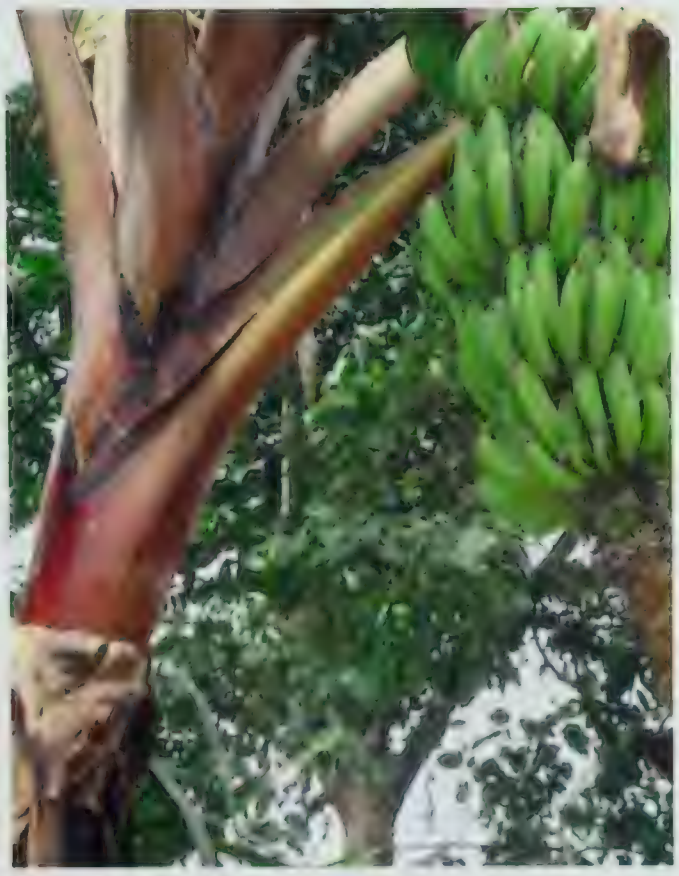
Erect: Tavi Lole

Figure 4.1 The different bunch orientations

Green: Lokoka

Dark green: Litete

Violet: Afati Noir



Red: Bokoka Liloka

Figure 4.2. Some pseudostem colors

Green: Bosakaraka | Dark green: Litete | Yellowish: Manimani | Red: Yelola | Brown: Ongua

Figure 4.3. Main colors of the immature fruit peel.

Very compact: Kodje | Compact: Bosua | Lax: Egbe-O-Mabese I

Figure 4.4. Bunch appearance

Straight: Apaka Magnige | Straight at the distal part: Libenga Likolo | Curved: Mosbikumu | Curved in 'S' shape: Egbe-O-Mabese I

Figure 4.5. Fruit shape (longitudinal curvature)

Salient: Libanga Liboelabokoi Intermediate: Kenjala Blunt: Apoka

Figure 4.6. Apex form.

- *Fruit apex*

The fruit apex can be salient (roughly bottle-necked with an irregularly angulate tip, with a rather plump acumen), blunt (absence of an acumen), and intermediate (the transition into the acumen is not abrupt, and the latter is hardly distinguishable) (Figure 4.6).

- *Fruit orientation*

The finger orientation is the composite result of the orientation of the floral axis, the pedicel constitution and its size. For 'normal' fingers, different possibilities in the orientation are shown in Figure 4.7.

- *Flower relics at the fruit apex*

Three different cases can be observed in plantain subgroup: apex without any floral relics, with persistent style or the base of the style prominent (Figure 4.8).

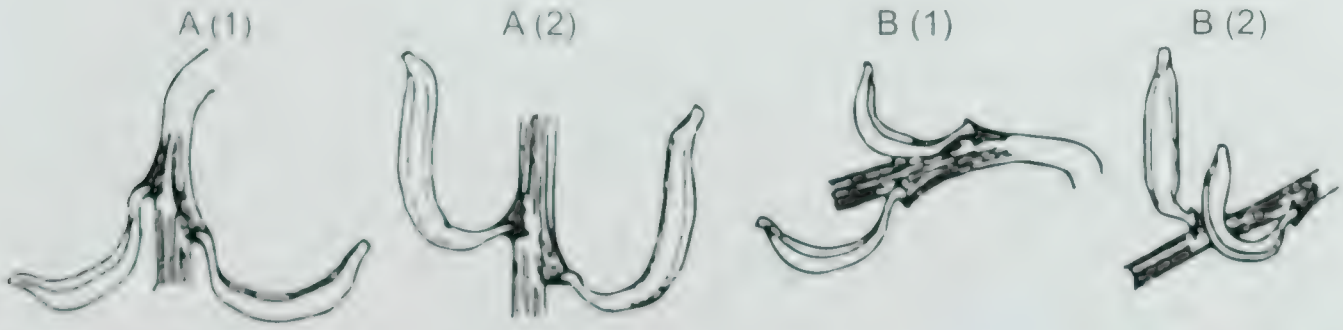


Figure 4.7. Finger orientation (De Langhe, 1961a). A: pendulous or sub-pendulous bunch with flexible pedicel (1) or rigid pedicel (2). B: Subhorizontal bunch with flexible pedicel (1) or rigid pedicel (2)

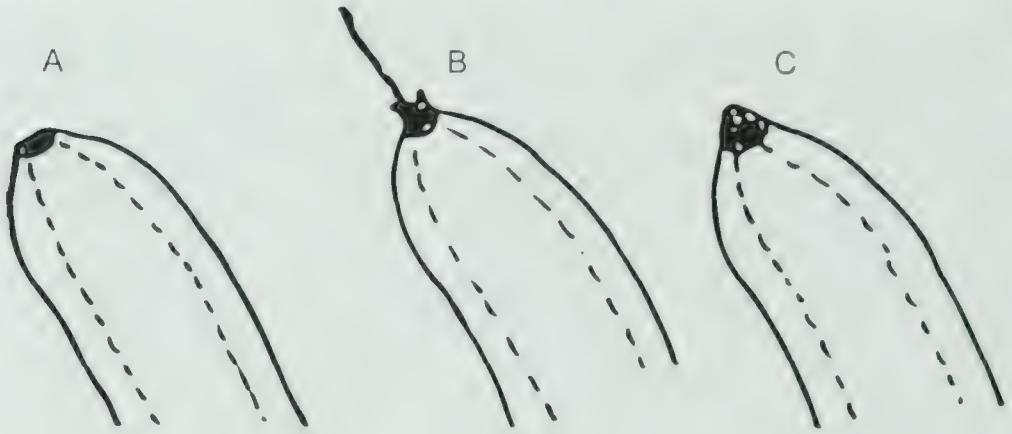


Figure 4.8. Remains of flower relics at fruit apex:
A: without any floral relics;
B: persistent style;
C: base of the style prominent.
(IPGRI-INIBAP/CIRAD, 1996).

- *Number of hands per bunch*

The number of hands per bunch often depends on growing conditions and environmental factors. However, some Giant plantain accessions for example can regularly develop more than 12 and up 16 to 20 hands, thus differentiating them from the usual Giants.

- *Number of fingers per hand*

The number of fingers per hand is unstable in the plantain subgroup. However, the finger number of the first hand is a fairly reliable trait to in distinguishing a few cultivars.

- *Fruit size*

Here again, absolute measures are only a value for extreme cases. For instance, accessions with a finger length regularly exceeding 25 cm can be differentiated from short-fingered accessions with a maximum length of 15 cm.

Rare descriptors

Beyond the above-mentioned secondary descriptors, a number of more rare traits exist in one or at the most two accessions. This is the case of the *spiraloid bunch* with all the fruits attached to one crown coiled around the stalk in the accession 'Aleke', the *uniseriate* position of the fruit on the crown, the fingers being arranged in a single row instead of the two usual rows ('Libanga Liboelabokoi', 'Libanga Liboelabokoi red', 'Bu Ambala', 'Bondele'), and the *unusually long pedicels* compared to the fruit length, in the accession 'Maboto'. These rare descriptors are illustrated in Figure 4.9.

Classification

All of the 96 identified accessions are classified in Table 4.2.

The table reflects the application of the adapted descriptors according to their degree of differentiating performance. The accessions are grouped according to the Main descriptors. The other descriptors are added as acronym to each accession. The names of the accessions without any color- or additional information are the 'basic' cultivars with

Spiraloid bunch: Aleke | Uniseriate fruit position: Libanga Liboelabokoi red | Long pedicels: Maboto

Figure 4.9. Rare descriptors in plantain subgroup.

green pseudostem, green pericarp (when immature), and fingers with salient apex. In Table 4.2 for the French with their generally pendulous or nearly pendulous bunch (PB), the corresponding acronym 'PB' has not been used, while SB (Subhorizontal bunch) or HB (Horizontal bunch) were added for the few exceptions.

A more practical but quite lengthy version of the tables is provided in Annex 5, whereby rare descriptors/states are included. The underlined accessions in Annex 5 are representative of the salient form differences and are illustrated in Annex 6.

Comparative discussion

French, False Horn and Horn plantains

The French plantains, with 64 accessions, are the most numerous in the UNIKIS collection, which comprises 97 plantain accessions. They are followed by False Horn plantains with 23 accessions and Horn plantains with 10 accessions only.

The larger number of French plantain accessions strengthens the hypothesis that False Horn and Horn plantains could have derived from French plantains by the phenomenon called "inflorescence degeneration" (Chapter 3). The morphological variation that is present along the French plantain accessions are also found in False Horn and Horn accessions. In contrast, no variation has been mentioned in the past or observed in the UNIKIS collection in False Horn or Horn plantain accessions without also being observed in the French plantain accessions. For instance, a dark green pseudostem and fingers are observed across the three types, 'Litete' (French with salient apex), 'Adili' (French with blunt apex), 'Libanga Dark Green' (False Horn with salient apex) and 'Moikih' (Horn

Table 4.2.a. UNIKIS accession identities: French plantain.

Small	Medium	Giant	Semi-Dwarf	Dwarf
Akpasi	Afati (Psr)	Akokailongo (Fr)	Akoy (IA)	Nguku (D)
Amagaba	Adili (BA;Psdg,Fdg)	Aleke (Sp)	Amuku (Psr;BA)	Yungu (D Psr)
Angb. (BA)[1]	Afati 'Wine Red' (Fr)	Amakoko I (IA)		
Boofo (IA;C)	Afati Black (Psb)	Andula (Psb;S)		
Boosa (IA;C,Psb)	Akadja (Psdg;Fdg)	Atili (Psdg;Fdg)		
Boofo Red (Psr)	Amakoko II (IA)	Bokoka liloka (Psr;BA)		
Engwe (Fr)	Bakpala (SB;Psr)	Boleko		
Gwekwele	Bhegisi (Psb)	Bolomaise (BA)		
Ifel(eng)ete	Bondele (Fy)	Bosakaraka I (S)		
Kenjala (Psr)	Bu Ambala	Bosakaraka II (S)		
Manimani (Fy)	Egbe-O-Mabese II	Bosua (Psr)		
Ngindaolo	Kambolokoso	Chwachwa		
	Luizi (Fy)	Inekeleikumi (IA)		
	Lolipili (Psdg;Fdg)	Ketota (Fy)		
	Maboto (SB)	Kpoolo (Psr;IA)		
	Magoma I (BA)	Kodje		
	Magoma II (BA)	Libanga Lib.[2]		
	Masekpe	Libanga Lib. Red (Psr)		
	Ongua (Fr)	Lindimama (BA)		
	Sika	Litete (Psdg;Fdg)		
	Sugbe (Psr)	Lokoka		
	Yelola (Psr;Fr)	Mongele (Psr;Fy)		
	Yumba	Wilingwa		
	Yumba Black (Psb)	Yeli (Fy)		

[1] Full name = *Angbonbgolia*

[2] Full name = *Libanga liboelaboko*

Table 4.2.a-c. *– Acronyms*

Bunch orientation

PB: pendulous or nearly pendulous, SB: subhorizontal, HB: horizontal

Pseudostem color

Psr: red (pink), Psb: violet–black, Psdg: dark green

Finger (peduncle) color before ripening

Fy: yellowish, Fbr: brown, Fr: red, Fdg: dark green

Other

(BA) = Blunt finger-apex

(C) = Curved fingers, less redressed, abaxial part less straight → more open bunch

(CH) = Chimeric pseudostem, generally green+yellow or green+ (wine) red

(IA) = (French) Intermediary apex form

(S) = (French) fingers of 1st hand(s) S-shaped, with apex bending outwards

(SD) = Semi-dwarf

(Sp) = Spiraled arrangement of hands

Table 4.2.b. UNIKIS accession identities: False Horn plantain. For the acronyms see table 4.2.a.

Small	Medium to Giant (G)	Semi-Dwarf
Akoto	Apoka (BA)	Apoka Magbuge (BA)
Amakake	Babele Ba Poku (Fy)	Bokpeta
Boon	Egbe-O-Mabese I	Mumuliagbia (HB)
Bubungu	Libanga Likale	
Leese	Libanga Lifombo (Psr)	
	Libanga Multiple	
	Libanga Black (Psb)	
	Libanga DarkGreen (Psdg;Fdg)	
	Lingu (PB ;Fy)	
	Kese	
	Mangweyangweya	
	Mogbokuma	
	Mongobe (Fr)	
	Nembundu (Fbr)	
	Taena Pambe (BA)	

Table 4.2.c. UNIKIS accession identities: Horn plantain. For the acronyms see table 4.2.a.

Pendulous bunch		Subhorizontal to erect bunch	
Small	**Medium**	**Giant**	**Dwarf**
Nselenge	Lokusu	Bokangasoku	Tala Lola
	Lokusu Red (Psr)	Ikpolo	
	Mongo	Ikpolo Red (Psr)	
		Ikpolo Black (Psb)	
		Moikili (Psdg;Fdg)	

with salient apex). But there are no 'dark-green' False Horn and Horn accessions with a blunt apex. This could mean that a number of cultivars from the 'Litete' lineage underwent variation that led initially to the False Horn 'Libanga Dark Green', and then to the Horn 'Moikili', while no individuals in the lineage of 'Adili' (blunt apex) have – as yet? – undergone variation of the inflorescence degeneration. Thus, the probability of variation expression looks related with the number of accessions in each type: about three times higher in the French type compared to the False Horns, and six times higher than the Horn plantains. Only a restricted number of 'popular' cultivars among French plantains would have been subjected to the 'degeneration' leading to False Horn and Horn forms.

Several other striking examples illustrate this explanation. The giant 'Akoka Hongo' and medium 'Ongua' French plantains both have a green fruit peel color in immature hands, progressively becoming red with maturity. This trait is also found in the False

Horn plantain 'Mongobe' but was not observed in Horn plantains. The black streaks on the pericarp of 'Sika' (French plantain) and 'Kese' (False Horn plantain) or the wine-red fruit peel before maturity of 'Yelola' (French plantain) and 'Nembundu' (False Horn plantain) are not observed in Horn plantain. Other variations are observed only in French plantain accessions: the spiraloid bunch of 'Aleke', the uniseriate position of fruits on the crowns of 'Libanga Liboelabokoi', and the long pedicels of 'Maboto'.

The difference between French, False Horn and Horn plantain cultivars is not always distinct. Indeed, gradations are detectable from one stage to another, thereby illustrating the phases shown on Table 3.1 of Chapter 3. In French plantains, for example, a reduction (along the inflorescence) is noticed in the flower number per glomerula, starting from the first hand. This decrease can be more or less pronounced, depending on the cultivar, and can lead in pronounced cases to nearly exhausted male buds at maturity (Tezenas du Montcel *et al.*, 1983). In other cultivars, this reduction of the male bud seems correlated with an increase in finger size. This is the case with 'Egbe-O-Mabese II', which has moderately large horn-like fingers, but neutral and male inflorescence parts like French plantains. In addition an exhausted male bud is present at the late stage of bunch maturity. The next degeneration step would be 'Egbe-O-Mabese I', which is a False Horn plantain (lack of the male bud at maturity), but with the same finger shape and a more than usual number of neutral 'hands'. In other cases, however, the degeneration seems to proceed differently, with a strong reduction in the number of fingers per hand but maintenance of the complete male inflorescence. A strange case is observed in 'Bu Ambala' and 'Bondele' which have a normal inflorescence with a male part, but with only one fruit per hand.

The gradual degeneration of the inflorescence can also be seen within the False Horn type with, for example, a decrease in the number of female and neutral hands from one cultivar to another. The cultivar 'Corne type' was found to have few female and neutral hands compared to other False Horn plantain cultivars (Tezenas du Montcel *et al.*, 1983). In a few cases, as with 'Egbe-O-Mabese I', there is a long rachis after the last female hand, as with French plantains, but the rachis is naked (without neutral flowers or bract relics). Another False Horn, 'Taena Pambe', has only a very short rachis after the last hand, looking at first sight like a Horn plantain.

Giant, medium and small plantains

Among the normal plantains, all three size categories exist only in the French plantain accessions of the UNIKIS collection, with 24 giant, 22 medium and 12 small cultivars. The very rare exceptions to the criteria combination rule proposed in Table 4.1 seem to point to an unusual morphology (and perhaps genotype). It is the case for the accession 'Inekeleikumi', which has more than 40 leaves (a typical trait in giant plantains) but a bunch with only six to eight fingers per hand (typical for medium plantains). However, this accession has an unusual finger shape (for plantains) similar to Pisang Awak (an ABB cooking banana).

In the False Horn accessions, the distinction in size is less pronounced, and none has the giant size of the French type. The 'giant' Horn plantains are also somewhat smaller than the French giants. Although the size categories are well represented in French plantains, the differentiating criteria for size categories are not always evident in all the cultivars.

Dwarfism

Dwarfism is a trait that apparently occurs randomly among the plantain accessions. The UNIKIS collection shows two semi-dwarf and two dwarf French plantain accessions, three False Horn semi-dwarfs and one Horn dwarf. The Yangambi collection had two dwarf and six semi-dwarf French plantain accessions, one dwarf and one semi-dwarf False Horn, and no dwarfism at the Horn type. The proportions roughly reflect the amount of representation of the three types in general.

Bunch orientation

The two recorded orientations, pendulous versus sub-horizontal bunch, are very differently represented in the three bunch types.

Among the French plantains, more than 90% of accessions have pendulous bunches, and the subhorizontal bunches belong to the Semi-dwarfs, except for the medium-sized accessions 'Bakpal' and 'Maboto'. In sharp contrast, only 4 of the 10 Horn plantain accessions have a pendulous bunch, and the 6 others show subhorizontal bunches. One could be inclined to explain the subhorizontal bunch orientation of the giant Horn plantain because of their smaller bunch sizes, but 85% of the small French plantain accessions, with their smaller bunches, have pendulous bunches as well.

The False Horn plantain accessions present somehow an intermediary orientation, in that the bunch is subhorizontal at the immature stage, evolving towards pendulous state at maturity. It is therefore important to record the orientation at or near maturity, when the bunch reaches its maximal weight.

Colors

The majority (57%) of the plantain accessions at the UNIKIS collection has a green pseudostem and green fruit peel before maturity. About the same proportion holds across the three types, the pseudostem size and the dwarfs.

The pseudostem is the plant part most commonly affected by color variation. Many cultivars with the same architecture differ only in pseudostem color, and the same color variants are observed across the three types. In False Horn plantain accessions, for example, three cultivars have exactly the same traits, except for the pseudostem color which is green in 'Libanga Likale', red in 'Libanga Lifombo' and black in 'Libanga Black'.

Fruit peel color before maturity is rarely associated with pseudostem color, and all kinds of pseudostem-fruit peel color combinations are observed. The most common combination is the red pseudostem and the green immature fruit peel (13% of cultivars). The False Horn 'Libanga Dark Green' differs from the three above-mentioned Libanga cultivars in that both the pseudostem and fruit peel are dark green. The green immature peel color can be black-streaked in cultivars such as the French plantains 'Sika', 'Bhegisi' and the False Horn plantain 'Kese', or white-streaked in the French plantain 'Boleko' and the False Horn 'Mangweyangweya'. Dark green (6% of cultivars) and red (1%) of both pseudostem and immature fruit peel are surprisingly rare among the UNIKIS accessions.

Other color combinations are: green pseudostem and yellow immature fruit peel (7%), green pseudostem and red immature fruit (6%), and red pseudostem and yellow immature fruit peel (2%).

Finally, the fruit peel color can evolve from emergence of the bunch to maturity. The most spectacular examples are the French 'Ongua' and the False Horn 'Mongobe' which both have a green fruit peel at bunch emergence, becoming progressively red at maturity.

Fruit shape and fruit apex

The fruit shape is helpful in differentiating very similar-looking cultivars. A striking example is the case of two False Horn accessions, Lingu and Babele Ba Poku. Both have the same morphology and yellow fruit peel color before maturity. The only descriptor that allows differentiation is the fruit shape. The first has a curved fruit shape while the second has a straight fruit shape.

The fruit apex can equally be very useful in differentiating plantain cultivars. For example, the prototype of False Horn plantain 'Libanga Likale' is different from 'Apoka' only because the first has a salient apex and the second a blunt apex. Another example is illustrated by the two small French plantain cultivars, 'Boofo' and 'Angbongbolia'. Both are similar in all charateristics except that the first has a salient apex while the second has a blunt apex.

Fruit position

The value of this descriptor is illustrated by of the accessions 'Boofo' and 'Gwekwele', which are both small French plantain cultivars with green fingers on a pendulous bunch. But the first has fingers perpendicular to the floral axis on an apparently flexible pedicel, while the second has fingers with a rigid pedicel and thus parallel to the floral axis.

Rare descriptors

In banana bunches, the fruits are arranged in hands attached to a separate crown on the rachis. However, in the giant French plantain accession 'Aleke', all the fruits are

attached to one unique crown coiled around the rachis, giving the bunch the appearance of a snail. Indeed, the name Aleke means 'snail' in Lombo, a Bantu language spoken in the Tshopo district.

The cultivars 'Libanga Liboelabokoi', 'Libanga Liboelabokoi red' and 'Ketot', have fruits that are arranged in a single row per crown ('uniseriate') instead of the standard two rows. The extreme cases 'Bondele' and 'Bu Ambala' have only one fruit per crown.

Although almost all plantain cultivars have a same pedicel length, some variation was noticed in the UNIKIS collection. The medium French plantain 'Maboto' has an extremely long pedicel, while an unusually short pedicel – associated with thick fingers – was observed in the French plantain Inekeleikumi and the False Horn plantain Apoka Magbuge.

Conclusion

The innovative adaptation of the description at the cultivar level and the ordering of the descriptors according to their degree of performance proved to be sufficiently useful for an elaborate differentiation among the nearly 100 plantain accessions of the UNIKIS collection. Because exactly the same variation was systematically reproduced in the collection during succeeding regeneration cycles, the stability of the variants was confirmed. The system also proved its value in cultivar identification across the many different farms visited in DR Congo, as will be described in Chapter 5.

Giant plantains predominate within the French type accessions. They are characterized by long bunches which contain many orderly arranged hands. Such bunches are easily and densely packed on a truck. However, their fingers are relatively small; they have a long vegetative cycle and are very susceptible to lodging due to winds. Many of the False Horn and Horn plantains are medium-sized. These medium-sized plantains comprise agronomically interesting cultivars because of their relative precocity and apparently higher resistance to dry periods. In addition, they also predominate beyond the rainforest. This is why the plantain production landscape across DR Congo in general is dominated by False Horn and Horn types although their diversity is in some regions far overshadowed by the diversity of the French clone set, especially in Oriental Province (cfr. Chapter 5). The latter diversity is due to the great importance of plantain for a long time as basic food for consumption in the villages of the rainforest region, causing many somatic mutations.

The UNIKIS collection and plantain diversity in DR Congo and in Africa

The description and classification of the 96 accessions at the UNIKIS collection is a good reference for investigating the plantain diversity in Africa. It also facilitates research in its representativeness towards plantain diversity in DR Congo and of Africa in general. Bearing in mind the previous existence of another important plantain collection in DR Congo (at INEAC-Yangambi), a prerequisite for the evaluation is to assess the number of different plantains and to identity new cultivars by the UNIKIS project.

Reconciliation between the UNIKIS and the INEAC-Yangambi collection

The former field collection at the INEAC Centre of Yangambi in the 1960s was the only important plantain collection in the past. The UNIKIS accessions can now be compared with that of INEAC-Yangambi using published descriptions (De Langhe, 1961a; 1964a). The respective accessions of the two collections were analyzed according to the descriptors as explained in Chapter 4. The comparison of these results are shown in Table 5.1 and subsequently discussed.

The 23 accessions from the INEAC-Yangambi collection that are not present in the UNIKIS collection differ in one or a few characteristics as seen in Table 5.2. However, some of them could be synonyms if planted at the UNIKIS collection and compared to its accessions.

A synoptic view of the distribution of the accessions over the UNIKIS and INEAC-Yangambi collections is provided in Table 5.3.

Even if, among the supposed exclusive Yangambi accessions, some synonyms within the UNIKIS collection would eventually be revealed, the total diversity of the subgroup in Africa could consist of more than 120 cultivars, if all potentially interesting villages should have been visited. Indeed, considering also the diversity in other countries of Central and especially in West Africa, the diversity of African plantain could even be substantially larger than 120 accessions. Theoretically, the various combinations of all the differentiating characteristics could indeed mean that the plantain diversity runs into hundreds of cultivars.

Table 5.1. Distribution of accessions.

In both collections	*At UNIKIS only*	*At INEAC-Yangambi only*
• **French Giant**		
Aleke	Akokailongo	Wale osombo
Bolomaise	Amakoko I	
Bosua	Atili	
Inekeleikumi	Boleko	
Libanga Liboelabokoi	Bosakaraka II	
Litete	Chwachwa	
Andula/Bosakaraka	Kpoolo	
Bosakaraka I/Losakala	Ketota	
Koko/Bokoka Liloka	Libanga Liboelabokoi Red	
	Lindimama	
	Lokoka	
	Mongele	
	Wilingwa	
	Yeli	
• **French Medium**		
Afati	Adili	Boloko
Afati black	Akadja	Bombutule
Afati Red Wine	Bakpala	Ikiokio
Yumba	Bhegisi	Ileli
Amakoko II/Otiti	Bondele	Isabolobaete,
	Bu Ambala	Losee
	Egbe-O-Mabese II	Okere
	Kambolokoso	Sogbe
	Lolipili	Wenge
	Luizi	
	Maboto	
	Magoma I	
	Magoma II	
	Masekpe	
	Ongua	
	Sika	
	Sugbe	
	Yelola	
	Yumba Black	
• **French Small**		
Boofo	Akpasi	
Boosa	Amagaba	
	Angbolia	
	Boofo red	
	Egwe	
	Gwekwele	
	Ifel(eng)ete	
	Kenjale	
	Manimani	
	Ngindaolo	

Table 5.1. (continued) Distribution of accessions.

In both collections	*At UNIKIS only*	*At INEAC-Yangambi only*
• French Semi-Dwarf		
Akoy/Koy Amuku	–	Atemeso Ndee Ikelekese Ituma Litete Li Koko
• French Dwarf		
Nguku	Yungu	Agwetuke
• False Horn Medium to Giant		
Apoka/ Libanga Ya Koko Libanga Likale Libanga Lifombo Libanga Black Mogbokuma/Libanga Type C	Egbe-O-mabese I Kese Libanga Dark Green Libanga Multiple Leese Lingu Mangweyangweya Mongombe Nebundu Taena Pambe	Monganga Nkonga Wangala
• False Horn Small		
Akoto/ Imbelenga Bubungu/ Andala	Amakake Babele Ba Poku Boon	–
• False Horn Semi-Dwarf		
Bogbeta/Bokpeta	Apoka Magbuge Mumuliagbia	–
• False Horn Dwarf		
		Bongokomi Tjene
• Horn Pendulous bunch, Medium		
Lokusu Lokusu Red Mongo/Suelanama		
• Horn Pendulous bunch, Small		
Ifelete /Nselenge		
• Horn Sub-horizontal to erect bunch		
Bokangasoku Ikpolo/ Igbulu Ikpolo Red/ Igbulu Red Ikpolo Black/ Bogboto	Moikili	Lofefa Tala
• Horn Dwarf		
	Tala Lola	

Table 5.2 The lost INEAC-Yangambi accessions.

Name	*Characteristics*
• **French giant**	
Wale Osombo	yellowish pseudostem and red/pink on petiole/sheaths wings
• **French medium**	
Agwetuke	dark-green variant of Nguku
Boloko	red pseudostem; intermediate fruit apex
Bombutule	faint salient apex
Ikiokio	red pseudostem; black streaks on fruit peel
Ileli	black pseudostem; dark-green fruit peel
Isabolobaete	resembling Yumba but after pollination experience at Yangambi was much more seed-fertile than Yumba
Losee	yellowish pseudostem; light-brown "flames" on exposed leaf-sheaths
Okere	green pseudostem; fingers not bending outwards or even bending inwards
Sogbe	faintly pronounced apex
Wenge	green pseudostem; finger tips strongly outwards bending
• **French Semi-Dwarf**	
Atemeso	subhorizontal bunch; "faint" fruit apex
Ndee	subhorizontal bunch; "faint" fruit apex; red pseudostem
Ikelekese	subhorizontal bunch; "gradual" fruit apex
Ituma	subhorizontal bunch; blunt fruit apex
Litete Li Koko	subhorizontal bunch; blunt fruit apex; dark-green pseudostem and fruit peels
• **False Horn medium**	
Wangala	pendulous bunch
Nkonga	red-wine pseudostem but green peel
Monganga	abrupt decrease to less than 4 fruits from hand 1 to hand 2
• **False Horn Dwarf**	
Bongokoni	subhorizontal bunch; "salient" fruit apex
Tjene	subhorizontal bunch; blunt fruit apex
• **Horn giant**	
Tala	yellow fruit peel before maturity
Lofefa	without any hand

Table 5.3. Presence of the plantain accessions in the UNIKIS and INEAC-Yangambi collections. ***B*** = present in both collections, ***U*** = present only in the UNIKIS collection, ***Y*** = present only in the INEAC-Yangambi collection, ***T*** = totals. N.A. = not applicable.

Type	*Bunch orientation*	*Pseudostem size*	*B*	*U*	*Y*	*T*
French	N.A.	Giant	9	14	1	*24*
		Medium	5	19	9	*33*
		Small	2	10	0	*12*
		Semi-Dwarf	2	0	5	*7*
		Dwarf	1	1	1	*3*
Total			*19*	*44*	*16*	***79***
False Horn	N.A.	Medium-Giant	5	10	3	*18*
		Small	2	3	0	*5*
		Semi-Dwarf	1	2	0	*3*
		Dwarf	0	0	2	*2*
Total			*8*	*15*	*5*	***28***
Horn	Pendulous	Medium	3	0	0	*3*
		Small	1	0	0	*1*
	Subhorizontal to erect	Medium-Giant	4	1	2	*7*
		Dwarf	0	1	0	*1*
Total			*8*	*2*	*2*	***12***
Grand Totals			**35**	**61**	**23**	***119***

Meanwhile, the 119 identified cultivars are basically covering the known diversity, and form a robust basis for further taxonomic assessments of plantains in Africa, as well as for evaluating the value of the plantains in different socio-economic situations. Most of the UNIKIS accessions which were absent in the INEAC-Yangambi collection are medium French plantains with a sub-horizontal bunch and small French plantains with a pendulous bunch. In contrast, sub-horizontal semi-dwarf French plantains are much less represented in the UNIKIS collection than they were in the INEAC-Yangambi collection.

Two possible reasons can help us to explain the large number of plantain cultivars in the UNIKIS collection in comparison to the INEAC-Yangambi collection. First, the INEAC-Yangambi collection is established about 65 years ago, making it possible that some 'new' cultivars arose during that time due to somatic variation. More importantly, the size of the explored area for collecting varied very much between both collections. Second, the INEAC-Yangambi collection missions were primarily undertaken in the Ishopo district and surrounding regions, yet UNIKIS missions were carried out in nine different provinces.

General assessment of plantain diversity in DR Congo

The UNIKIS collection nearly completely covers the possible plantain diversity in DR Congo

The Plantain germplasm surveys have been carried out in 66 territories across Oriental Province, Equateur, Maniema, northern Katanga, both Kasai's, and Bandundu in DR Congo. Figure 5.1 provides the districts where the 61 typical UNIKIS accessions (Table 5.3) were collected.

While the vast majority of the UNIKIS accessions was collected in the Province Orientale, additional accessions coming from other provinces are mentioned in Table 5.4.

Three provinces, where plantains are grown, were not explored because they have a local collection: Bas-Congo (INERA Mvuazi collection), North Kivu (collection at the University of Graben, Butembo) and South Kivu (INERA Mulungu collection). Although it is expected that most of their accessions are synonymous to the UNIKIS accessions, they may contain some local-specific variants adapted to savanna or higher altitude. Visits and exchange of information between the curators should meet the minor hiatus (see below, 'A Pan-African scope of plantain diversity' item 'Practical outlooks').

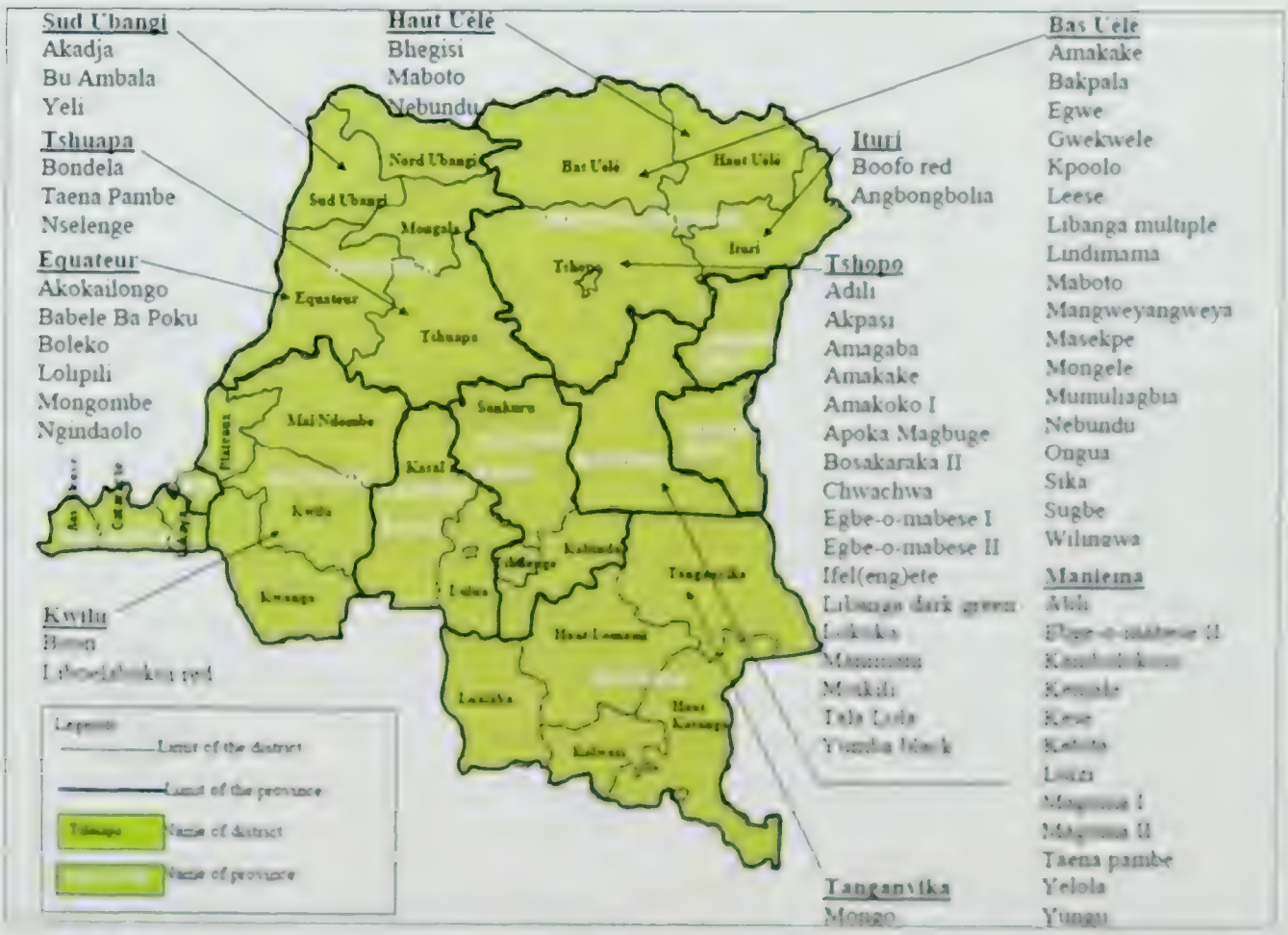


Figure 5.1. Districts of UNIKIS recorded plantain accessions

Synonymy and nomenclature do have a multiple significance

About 200 different, mostly Bantu languages/dialects are used by farmers in the surveyed region as indicated in Figure 5.2. Hence, a considerable number of synonyms have been recorded during the exploration missions as shown in Annex 4. However, due to time constraints, only a few villages in these districts were selected for more in-depth surveys that could help reducing the number of possible synonyms in the visited areas.

Table 5.4. Additional cultivars collected from other provinces than Province Orientale.

Province	*Accession name*	*Type and size*
Equateur	Akadja	Medium French
	Akokailongo	Giant French
	Babele Ba Poku	Medium False Horn
	Boleko	Giant French
	Bondela	Medium French
	Bu Ambala	Medium French
	Lolipili	Medium French
	Mongombe	Medium False Horn
	Ngindaolo	Small French
	Nselenge	Small Horn
	Yeli	Giant French
Maniema	Taena pambe	Medium False Horn
	Atili	Giant French
	Kambolokoso	Medium French
	Kenjale	Small French
	Kese	Medium False Horn
	Ketota	Giant French
	Luizi	Medium French
	Magoma I	Medium French
	Magoma II	Medium French
	Yelola	Medium French
	Yungu	Dwarf French
Bandundu	Boon	Small False Horn
	Liboelabokoi red	Medium French
Katanga	Mongo	Medium Horn

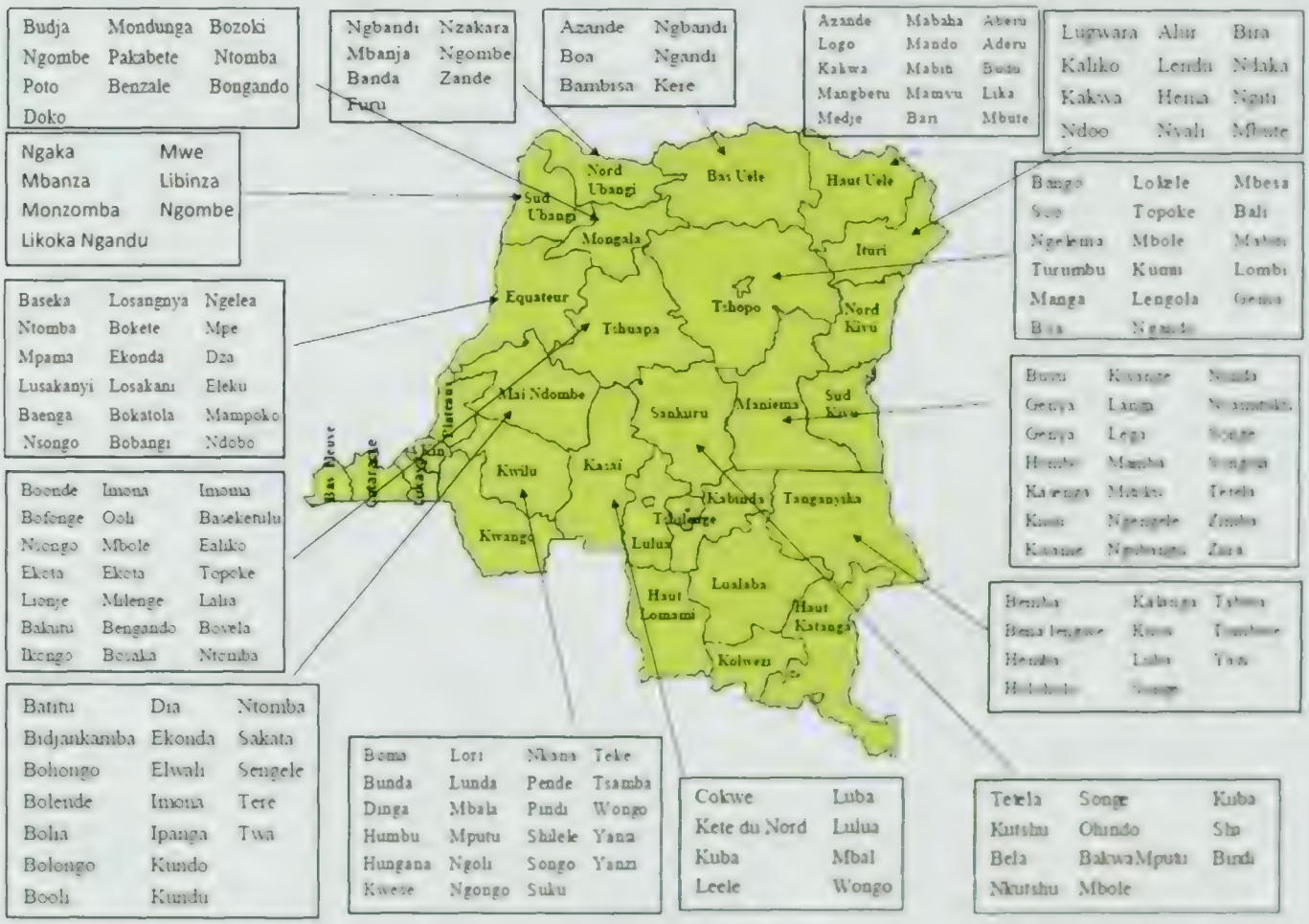


Figure 5.2. Dialects in DR Congo districts where the plantain collection missions have been conducted.

This is possibly one of the reasons why synonyms of several cultivars identified in one district or language area have not been recorded in other districts areas. There is thus a real need for a further exhaustive plantain diversity study in these districts.

Synonymy assessment is not only important to avoid duplications at the collection level but also presents several other advantages in a broader context. The knowledge of local synonyms of any collected and studied cultivar allows for a better extrapolation to other areas of farmers'/consumers' interests, thus enriching research insights. This could be useful in terms of cultivar importance as cultivars with more recorded dialects are probably among the most important ones. At a larger scale, reports or publications mentioning local cultivar name(s) can be correctly interpreted when it turns out that the names are synonyms of well-studied accessions of an important collection such as that at UNIKIS.

The synonymy assessment of a large region is of great help in detecting specific diversity in parts of that region. The appearance of the same or similar terms/phonemes for a given cultivar in different languages can point to a common origin and even a shared history. This can be a strong indication of the value of a cultivar, both in agronomical and cultural terms. For instance, Libanga Likale which is the prototype of False Horn

plantains, is called Ambulu, Mbulu or Ngulu across all surveyed villages of DR Congo. In a few villages, however, specific names are also used for this cultivar. The cultivar is agronomically important and is the most widespread across DR Congo. In the Tshopo district (Oriental Province) for example, 71% of plantain mats recorded on farm were Libanga Likale (Adheka *et al.*, 2013).

The results in Annex 4 can already provide a large amount of information on cultivar distribution across the studied region. Cultivars which have a lot of synonyms recorded could be considered as most widespread. This is the case for Libanga Likale, Litete, Libanga Lifombo and Ebge-O-Mabese I. Other cultivars are only confined to a small area in the same linguistic zone. Thus, these cultivars may have only one synonym or none at all. This is the case for Mongo in the Tanganyika district, Mangweyangweya in the Bas Uele district and Ifel(eg)ete in the Tshopo district.

Names used by farmers in plantain taxonomy generally refer to a particular trait of cultivars. It can be the color of the pseudostem finger for Litete or Adili (= dark green) and Lifombo (= red) for example, the length of the plant for Basakaraka (= long plantain), the size of the bunch for Akpasi (small bunch), size of the hands for Libanga Likale (big hands), etc. This practice often leads to confusion between cultivars having similar traits. For example, the name Asau Losau given to Litete is also used for Adili in the same Kumu village. Even specific names like Sombo Kasombo are used for Libanga Lifombo. Generally, False Horn plantain cultivars with big fingers like Libanga Likale, Libanga Lifombo, Libanga Black, even Libanga Dark Green are called a-Mbulu, especially in regions where the South-central Sudanese language is spoken or where the term is used as a loanword in Bantu

All together, synonymy and nomenclature studies permit a greater understanding of plantain diversity across DR Congo provinces. Provinces with more recorded synonyms can be considered to contain a larger plantain diversity. Districts of Oriental Province have a high number of synonyms and newly recorded cultivars. For example, the cultivars Manimani (Tshopo district), Mangweyangweya (Bas Uele district), Maboto (Bas Uele and Haut Uele districts) and Masekpe were only recorded in Oriental Province. Other provinces, such as Equateur and Kindu had a large number of synonyms.

In general, the lower plantain diversity in the south of the country is correlated to the disappearance of the rainforest along the same direction, and the crop is thereby progressively replaced by savanna-adapted crops. Whereas plantain is a staple food for the majority of the ethnic groups in the northern forest zones of DR Congo (Sebasigari, 1985), cassava and maize are a source of nutrition for most ethnic groups in the southern provinces of DR Congo (Luba ethnic group in both Kasai and Katanga or Kongo ethnic group in Bandundu for example).

Figure 5.2 shows the districts of higher density of the newly recorded accessions of the UNIKIS collection (Table 5.7, U-columns). They most probably reflect the areas of highest plantain diversity and are mostly confined to the region where (Eastern) Central-Sudanic-speaking people live.

The high diversity can also be explained by historical arguments. De Langhe (2007) shows that Central Sudanic-speaking people are established over a larger part of the Oriental Province (Figure 5.3). This region corresponds with the zone of high plantain diversity. De Langhe (2007) postulates that these people settled in the region before the arrival of the Bantu people, with a longer 'plantain history' as a result.

From a historical perspective

Since it is likely that somatic mutations are the main cause of cultivar diversification, the number of cultivars in a certain region would be positively correlated with the length and intensity of plantain cultivation. The higher density in newly recorded accessions of the UNIKIS collection from northern DR Congo, as shown on Figure 5.2 most probably reflects a deeper historical past. The areas of highest plantain diversity are mostly confined to the region where (Eastern-) Central-Sudanic-speaking people live.

It has indeed been demonstrated that '*konde*', the generic name for plantains in Bantu languages was used first in the rainforest region and that it spread later on to the south and southeast of the DR Congo (De Langhe *et al.*, 1994-5)

The highest diversity in the eastern part of the rainforest zone of DR Congo may be connected to the Central Sudanic-speaking population there. De Langhe (2007) mentions that Central Sudanic-speaking ancestors were established over a large part of the Oriental Province and that their language provided many loanwords (including '*bugu*' for plantain) to the Bantu ethnic groups who later became established in that region. As a result, these Central Sudanic people probably have the longest 'plantain history',

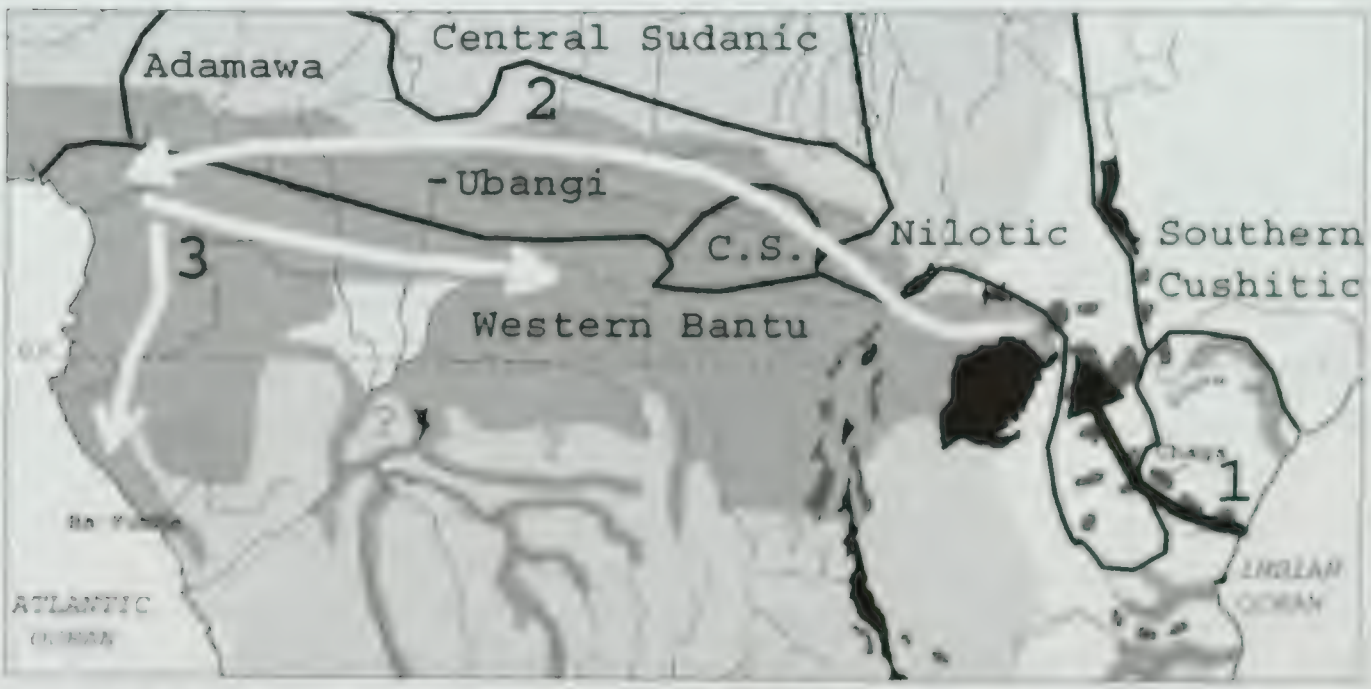


Figure 5.3 Possible route of plantain diffusion across central Africa, with major language phyla displayed (Source: De Langhe, 2007) (C.S.: Central Sudanic)

thereby generating the highest plantain diversity. Figure 5.3 is a tentative reconstruction of how plantains reached the rainforest. Plantains were (1) carried over the northern and peripheral zone of the rainforest to eventually (2) meet the Bantu ancestors in present Cameroon, who (3) during their expansion over Africa spread the crop in several directions. Figure 5.3 points out how the Central Sudanic speaking ancestors could be the first ones to cultivate the plantains.

Conclusion

The UNIKIS plantain collection demonstrates that medium French plantain cultivars are the most numerous in all the surveyed regions across DR Congo. In addition, considering color variation, it was noted that medium green plantain cultivars were the most numerous and were very common in this vast region. Consequently, the medium French type with green pseudostem color is probably the prototype of the plantain subgroup, and can be as assumed to be at the origin of the False Horn and Horn plantain types and the multiple color variations. However, the latter two types are the most widespread on-farm, reflecting their agronomic and marketing values and or their capacity to grow in various ecological conditions.

Many of the interesting dwarf semi-dwarf plantains of the Yangambi collection are not yet in the UNIKIS collection. They need to be collected and introduced to the collection. Hence, the regions from where they were previously collected need to be revisited. In addition, a thorough collection and characterization effort needs to be undertaken in all the DR Congo districts. This would make it possible not only to detect other cultivars which are not yet in the field collection, but will also allow the expansion of the local synonymy assessment. By these means, a correct interpretation of a large part of DR Congo farmers'/consumers' experience with cultivars can be developed, thus enriching the agronomic/marketing insight.

For more complete plantain diversity knowledge in DR Congo, reconciliation efforts are also needed with other collections, such as with the Butembo and Mulungu collections in the higher altitude North-Kivu province, and the Mvuazi collection in the Bas-Congo province. Subsequently, the reconciliation effort could be extended to collections elsewhere in Africa, such as the extensive Nyombe collection in Cameroon. This will lead to a nearly complete knowledge of plantain diversity in Africa.

A Pan-African scope of plantain diversity

A proposed core plantain diversity for Africa

The combined data from the UNIKIS collections and from the previous Yangambi collection are a reference basis for the pan-African scale of plantain diversity.

It is here postulated that a limited set of cultivars is likely to be present in most of the plantain cultivation areas and form the 'backbone' of plantain diversity. Indeed, one

can learn from Table 4.2 that 57 of the 119 accessions are merely color variants. Color variation in plantain in DR Congo is of minor economic importance, as it has hardly any influence on market prizes. The cultural importance of color, however, should not be underestimated in the traditional context. In total (119 - 57 =) 62 'green cultivars' re-

Table 5.5. Postulated core set of rather ubiquitous plantain cultivars.

	Pseudostem size	Other differentiating descriptors	Cultivar names
French			
1	Giant	≤ 12 hands	Chwachwa
2		≥ 13 hands	Losakalaka (S)
3		Spiraloid bunch	Aleke
4		< 8 (horn-like) fingers/hand	Libanga Liboelabokoi
5	Medium	< 5 hands	Yumba
6		6-8/9 hands	Okere
7			Wenge (S)
8		< 8 (horn-like) fingers/hand	Egbe-O-Mabese II
9	Small	Prototype	Boofo
10		Fingers shorter (than on Boofo)	Akpasi
11		Fingers longer	Amagaba
12	Semi-dwarf	Prototype	Atemeso
13		With swollen style base	Akoy
False Horn			
14	Medium to Giant	Prototype	Libanga Likale
15		First hand points upwards	Egbe-O-Mabese I
16		<4fingers on ≤ 5 hands	Monganga
17	Small	Curved fingers	Amakake
18		Straight fingers	Boon
19	Semi-dwarf	Longer male axis than Libanga	Bokpeta
Horn			
20	Pendulous/Medium	Prototype, ≤ 4hands	Lokusu
21		>4 hands	Mongo
22	Pendulous/Small	Prototype	Ifelete
23	Sub-horizontal/Medium to Giant	Prototype	Ikpolo

S = fruits of first hand in S-shape, with apex bending outwards

main from which the color variants were derived and which consist of two variant types: (1) finger apex variants (blunt or intermediate instead of salient) and (2) rather 'unique' green cultivars, very distinct in a particular bunch morphology and likely not existing in many other parts of Central and West Africa. When disregarding both variant types, a core set of 23 cultivars can be obtained (Table 5.5).

With the addition of the apparently frequent variation 'blunt' and/or 'intermediate' finger apex, about 30 cultivars are estimated as 'common green cultivars'. We propose that this core-set serves as the reference for further taxonomic research on plantains in Africa. These cultivars are most likely cultivated across the entire plantain zone in DR Congo, or at least in its most humid parts. Their cultivation for centuries has produced the many color and other variants, and their names developed almost as many synonyms as the number of involved Bantu Sudanese Nilotic Ubangi languages.

The local extent of variation would depend on the degree of importance of the crop to a tribe. The extraordinary phenotypic diversity of the plantains displays almost all what somaclonal variation can achieve (De Langhe *et al.*, 2009). This can serve as a model for the variation in other subgroups. Indeed, the Pacific Maoli-Popo'ulu subgroup shows to a large extend a similar variation (Ploetz *et al.*, 2007), while somatic variation in other subgroups seems to be more moderate, perhaps indicating a more recent genesis and history.

The UNIKIS collection and the accessions in West Africa

An exhaustive review of plantain diversity in West Africa has been made by Swennen (1990). Table 5.6 is an adapted version which demonstrates that the main divisions of plantain diversity used in the present work are valid for West Africa.

The entire range of variation at the UNIKIS-Yangambi collections is observed in West-Africa. Nevertheless, several details in the footnotes of the tables seem to point to different cultivars, or else to features that were not noticed at the UNIKIS and Yangambi collections. A number of UNIKIS accessions do not seem to be recorded in West-Africa while some accessions are missing at UNIKIS (see below, sub 'Practical outlooks').

It can be concluded that the classification of the plantain accessions at the UNIKIS collection, and especially the 'core set' (Table 5.5) can be used as a standard for the investigation of plantain diversity for the entire African continent.

Genetic significance of the plantain diversity in Africa

Molecular findings seem to substantiate the assumption that the entire plantain diversity in Africa is derived from only one or a few introduced basic plantain hybrids in the past, and that this impressive diversity must have been generated over centuries (or even millennia) of cultivation on the African continent via somaclonal variation (De Langhe *et al.*, 1994-1995).

Indeed, the current techniques to identify genetic variation such as SSR and DArT have not been able to detect genetic variation despite the evident morphological variation (Noyer *et al.*, 2005; Hippolyte *et al.*, 2011). However, the same techniques proved to be very effective in differentiating higher-level banana sets such as subgroups, edible AA, and subspecies of *M. acuminata*. In consequence, it can be concluded that 'the high (morphological) diversity is a consequence of a necessarily long phenotypic differentiation' (Perrier *et al.*, 2009). 'Phenotypic' implies that the genotype is not changed and would in the present case be caused by somatic variation without mutations. Recent unpublished indications from 'genotyping by sequencing' analyses seem to point again to lack of power to differentiate the plantain cultivars at the genotypic level (De Langhe, pers. information.).

These results increasingly confirm the hypothesis that the exceptionally high plantain diversity in Africa has a predominantly (or exclusively) *epigenetic* origin, and that all the variants are the result of different gene expressions that became fixed by vegetative propagation.

Practical outlooks

A concerted study of the major plantain field collections in Africa would not only allow for an almost complete taxonomical understanding of the crop, but also form a solid basis for a long-term pan-African investigation of not-yet-recorded cultivars and synonyms. The progressive result would considerably facilitate all other research on plantains.

Within DR Congo and apart from the UNIKIS collections, three important collections are active: two in the mountainous eastern region, Butembo, University of Graben

Symbols and acronyms Table 5.6.a.-c, pages 63-65.

Pseudostem color: **Rps**, red (pink); **Pswr**, wine-red; **Psbr**, brown-red; **Psb**, violet-black; **Psdg**, dark green.

Finger (pericarp) color before maturity. **Fy**, yellowish; **Fbr**, brown; **Fr**, red, **Fdg**, dark-green

Other
<4f = Less than 4 fingers on hand 2
≤ 5 Hd = 5 or less hands
BA = Blunt finger-apex
C = Fingers less redressed, abaxial part less straight → more open bunch
CH = Chimeric pseudostem, generally green+yellow or green+(wine)red
IA = (French) Intermediary apex form
PB = Pendulous Bunch
S = (French) fingers of 1st hand(s) S-shaped, with apex bending outwards
SB = Subhorizontal Bunch
SD = Semi-Dwarf
Sp = Hands connect in a spiraloid arrangement

Notes Table 5.6.a

[1] Pedicels fused
[2] Green+red pseudostem
[3] Bunch regularly with many aborted fruits (not a stress effect)
[4] Pseudostem yellowish green
[5] Neutral flowers partly deciduous
[6] Fingers pendent
[7] Fingers with brown tinge at maturity
[8] Both pseudostem and fingers
[9] Red fingers
[10] Pedicels fused
[11] Frequent synonym = *N'seluka* (see Nigeria)
[12] Pseudostem yellowish green
[13] Fingers with red stripes at (near?) maturity

Tables 5.6.a. Plantain accessions in West-Africa: French plantains. (Adapted from Swennen 1990)

Giant	Medium	Small or Semi-Dwarf	Dwarf
• *Ghana*			
Osabum (IA; S)	Onniaba (IA) [1] Nyiretia apem (BA)	–	–
• *Nigeria*			
Bo-Ahui-Abwe (Psr) Ntanga 2 (IA) Ntanga 5 (IA; S) Ntanga 6 Ovang (Psb)	Akpakpak (Psr; BA) Cantebalon (IA; C) Egjoga (BA) Mbi Egome 3 (Psr) Ntanga 3 (Fbr; IA) Ntanga 4 (IA) [2] Obino l'Ewai (IA) Obubit Ntanga 1 (Psb; IA) Obubit Ntanga 2 (Psdg; Fdg)	Mbi Egome (SB; IA) Nselouka (IA; C)	–
• *Cameroon*			
'Madre del platanar' [3] Mbouroukou N°2 (IA) Ndingo Liko (Sp) Niabang (Fbr; IA) Njombe N°1 (IA; S) Nyombe N°2 (Psr) Okele (BA) Zue Ekon (Fr; IA)	Amou [4] Ekona (Kwa) [5] French clair (IA) French rouge (Psr; BA) French sombre (Psdg, Fdg) Kar Ngou (SB; Fbr) Lifongo Liko (BA) Lipfo (Fy; IA) [6] Mbeta 1 (Psr) [7] Moto moLiko (SB,CH) [8] Ndem Bia (IA; C) Ntie (Psr; IA) [9] Plantain N°2 (Psb; IA) [10] Rose d'Ekona(Psr) Rouge de Loum (Psr; IA)	Bobby Tannap (SD) Elat (IA; C)	Njock Kon (IA) Red Yade
• *Gabon*			
Baka (Psb) Digonda dibala (IA; S) Mpizina (Sp)	Biri (IA) Esège? (SB ; CH) Ibata [12] Kuku (IA; S) Mundu (Fbr; IA) Mutuka 1 (Psbw) [13] Taba (Psdg; Fdg) Tsiegi (SB; IA	Elata (IA; C) [11]	–

Tables 5.6.b. Plantain accessions in West-Africa: False Horn plantains. See page 62 for the explanation of the symbols and acronyms used in this table. (Adapted from Swennen 1990)

Medium to **Giant** (G)		**Small** or **Semi-Dwarf**
• *Ghana*		
B(o)rode hene		Abomienu [14]
B(o)rode kokwa (PB; Fy)		Apantu pa [15]
Borodewuio (Psb)		Kaamenko [16]
		Nyiretia apantu
		Osobaoso [17]
• *Nigeria*		
Agbagba	Mimi Abue (Pswr; G)	
Atali Kiogo (PB) [18]	Ngok Ekome (BA)	
Bise egome 2 (PB)	Obubit Ukom (Psb)	
Eba oboikpa (PB; Fy)	Ogoni red (Psbr; G)	
Eberedia Ukom (Fb)	Okoyo Ukom (Psr)	
Kiogo (PB) [19]	Orishele (Psbr	
Mbang Okon [20]	Red Ukom (Psr;<4f)	
Mbiniryong(Pbr; CH)	Ukom (<4f)	
• *Cameroon*		
Batard (G) [21]	Mbouroukou N°1 (PB; Fy)	Corne 4 (Psb)
Big Ebang (G) [22]	Mbouroukou N°3 (BA)	Ebibi (Fr)
Corne type E36	Moto Ebanga (CH)	Essong
Esang (Fb)	Nzorba (Psb)	
Mbeta 2 (Pswr)	Plantain N°17 (Pswr)	
Mbindi (Psb; BA)	Red Ebanga (Psr)	
• *Gabon*		
Didungu (PB; Fy)	Mutuka 2 (PB ; Fr) [23]	
Ebang	Muvangi (<4f; ≤ 5 Hd)	
Mufubila (Fb)		

Notes Table 5.6.b.

[14] Probably collective name for plants with bunch dichotomy

[15] ≤ 5 neuter fingers

[16] 'Small, frequently ill-developed fingers, occasionally viable seed'. (Source Karikari, 1976)

[17] >35 fingers per bunch

[18] Hands semi-erect to pendent, neutral flowers along the entire male axis at maturity

[19] As *Atali Kiogo* but neutral flowers mostly dropped at maturity

[20] Wine-red petiole margins

[21] With > 60 fingers per bunch

[22] With > 60 fingers per bunch

[23] Fruit pericarp with red tinge before maturity

Tables 5.6.c. Plantain accessions in West-Africa: Horn plantains. See page 62 for the explanation of the symbols and acronyms used in this table. (Adapted from Swennen 1990)

Pendulous bunch				Sub-horizontal to erect bunch
Small	**Medium**			**Giant**
	All hands pendent	*First hands erect* [24]	*All hands erect*	*All = presumed variants of 1 basic cv (0-6 Hd = number of hands)*
• *Ghana*				
–	–	–	–	Osakro (1Hd); Asamienu (2Hd); Asamiensa (3Hd); Asanan (4Hd)
• *Nigeria*				
–	–	Ihitisim	–	Bise egome 1 (1-2 Hd); Ubok iba (2-4 Hd) [25]
• *Cameroon*				
–	–	–	Lysoka	Mongalove (1 Hd) [26]; Iba (1-2 Hd); Mota moliko, Mbomo (Fy; 2-4 Hd),
• *Gabon*				
–	–	–	–	Mbondu?

Notes Table 5.6.c.

[24] With a curve, but main 'body' pointing upwards

[25] Petiole margins wine-red

[26] In case of 0 hands, called *'Nothing but green'* or *'Nothing but red'* (for red pseudostem)

(c. 52 cultivars; Blomme, pers. comm.) and INERA Mulungu station (c. 30 accessions), and one in the savanna region, INERA Mvuazi station.

Beyond DR Congo, only two important collections are subject of sustained taxonomical study: at CARBAP (Nyombe, Cameroon) with 135 cultivars (Fondi, pers. comm.) and at the IITA (Ibadan, Nigeria) with 72 cultivars (Amah, pers. comm.).

Clearly, each of these collections would contain a number of region-specific cultivars, plus a probable large number of synonyms. The altitudinal collections may contain accessions that seem to be adapted to higher altitudes. The planting of these high altitude phenotype candidates at lowland collections and vice versa would at once reveal whether such 'altitudinal' ecotypes are genuine (growing less well at lower altitude) or simply expressing the ecological flexibility of plantain cultivars (growing perfectly on both lowland and high altitude).

The challenge is to have an exhaustive comparison of all these accessions. Planting all the accessions in one location is not feasible due to financial constraints. Instead we propose that curators embark in a sustained intensive mutual contact, with regular visits and discussions, in order to reach a progressive agreement on synonymy and uniqueness of accessions, and to construct a reliable pan-African classification of the plantains.

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Annexes

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Only available as a digital version: https://doi.org/10.5281/zenodo.1211612

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Annex 2. Non-variable and variable characters in African plantains

Non-variable	Variable
6.1 Plant general appearance	
	6.1.1 Leaf habit
	6.1.2 Dwarfism
6.2 Pseudostem/suckers	
6.2.2 Pseudostem aspect	6.2.1 Pseudostem height [m]
6.2.4 Pseudostem appearance	6.2.3 Pseudostem colour
6.2.7 Sap colour	6.2.5 Predominant underlying colour of the pseudostem
6.2.8 Wax on leaf sheaths	6.2.6 Pigmentation of the underlying pseudostem
6.2.10 Development of suckers	6.2.9 Number of suckers
6.2.11 Position of suckers	
6.3 Petiole/midrib/leaf	
6.3.3 Petiole canal leaf III	6.3.1 Blotches at the petiole base
6.3.4 Petiole margins	6.3.2 Blotches colour
6.3.5 Wing type	6.3.9 Leaf blade length [cm]
6.3.6 Petiole margin colour	6.3.10 Leaf blade width [cm]
6.3.7 Edge of petiole margin	6.3.11 Petiole length [cm]
6.3.8 Petiole margin width	6.3.12 Colour of leaf upper surface
6.3.13 Appearance of leaf upper surface	6.3.14 Colour of leaf lower surface
6.3.15 Appearance of leaf lower surface	6.3.17 Insertion point of leaf blades on petiole
6.3.16 Wax on leaves	6.3.22 Colour of cigar leaf dorsal surface
6.3.18 Shape of leaf blade base	
6.3.19 Leaf corrugation	
6.3.20 Colour of midrib dorsal surface	
6.3.21 Colour of midrib ventral surface	
6.3.23 Blotches on leaves of water suckers	
6.4 Inflorescence / male bud	
6.4.5 Peduncle hairiness	6.4.1 Peduncle length [cm]
6.4.9 Flowers that form the fruit	6.4.2 Empty nodes on peduncle
6.4.13 Rachis appearance	6.4.3 Peduncle width [cm]
6.4.15 Male bud shape*	6.4.4 Peduncle colour
6.4.16 Male bud size*	6.4.6 Bunch position
	6.4.7 Bunch shape
	6.4.8 Bunch appearance
	6.4.10 Fruits
	6.4.11 Rachis type
	6.4.12 Rachis position
	6.4.14 Male bud type
6.5 Bract	
6.5.1 Bract base shape*	
6.5.2 Bract apex shape*	
6.5.3 Bract imbrication*	
6.5.4 Colour of the bract external face	
6.5.5 Colour of the bract internal face	
6.5.6 Colour on the bract apex	

Non-variable	Variable
6.5 Bract	
6.5.7 Colour stripes on bract	
6.5.8 Bract scars on rachis	
6.5.9 Fading of colour on bract base	
6.5.10 Male bract shape*	
6.5.11 Male bract lifting*	
6.5.12 Bract behaviour before falling*	
6.5.13 Wax on the bract	
6.5.14 Presence of grooves on the bract	
6.6 Male flower	
6.6.1 Male flower behaviour*	
6.6.2 Compound tepal basic colour*	
6.6.3 Compound tepal pigmentation*	
6.6.4 Lobe colour of compound tepal*	
6.6.5 Lobe development of compound tepal*	
6.6.6 Free tepal colour*	
6.6.7 Free tepal shape*	
6.6.8 Free tepal appearance*	
6.6.9 Free tepal apex development*	
6.6.10 Free tepal apex shape*	
6.6.11 Anther exsertion*	
6.6.12 Filament colour*	
6.6.13 Anther colour*	
6.6.14 Pollen sac colour*	
6.6.15 Pollen vitality [%]*	
6.6.16 Style basic colour*	
6.6.17 Pigmentation on style*	
6.6.18 Style exsertion*	
6.6.19 Style shape	
6.6.20 Stigma colour*	
6.6.21 Ovary shape*	
6.6.22 Ovary basic colour*	
6.6.23 Ovary pigmentation*	
6.6.24 Dominant colour of male flower*	
6.6.25 Irregular flowers*	
6.6.26 Arrangement of ovules*	
6.7 Fruit	
6.7.5 Transverse section of fruit	6.7.1 Fruit position
6.7.10 Pedicel surface	6.7.2 Number of fruits
6.7.11 Fusion of pedicels	6.7.3 Fruit length [cm]
6.7.14 Fruit peel thickness [mm]	6.7.4 Fruit shape (longitudinal curvature)
6.7.15 Adherence of the fruit peel	6.7.6 Fruit apex
6.7.17 Pulp in fruit	6.7.7 Remains of flower relicts at fruit apex
6.7.20 Fruits fall from hands	6.7.8 Fruit pedicel length
6.7.21 Flesh texture	6.7.9 Fruit pedicel width [mm]
6.7.22 Predominant taste	6.7.12 Immature fruit peel colour
6.7.23 Presence of seed with source of pollen	6.7.13 Mature fruit peel colour
6.7.24 Seed surface	6.7.16 Cracks in fruit peel
6.7.25 Seed shape	6.7.18 Pulp colour before maturity
	6.7.19 Pulp colour at maturity

* Descriptors that are partly or completely inapplicable to False Horn and Horn plantain

Annex 3. Differentiation between the subgroups AAB Plantain and AAB Maoli-Popo'ulu, based on the non-variable descriptors for plantains

The diverging descriptor cases are in bold.

Descriptors	Plantain	Ainu (Maia Maoli)
6.2.2 **Pseudostem aspect**	Normal	Robust
6.2.4 **Pseudostem appearance**	Dull (waxy)	Shiny (not waxy)
6.2.7 Sap colour	Watery	Watery
6.2.8 Wax on leaf sheaths	Moderately waxy	Moderately waxy
6.2.10 **Development of suckers**	Between 1/4 and 3/4 of the height of the parent plant	More than 3/4 of the height of the parent plant
6.2.11 Position of suckers	Close to parent (vertical growth)	Close to parent (vertical growth)
6.3.3 **Petiole canal leaf III**	Margins curved inward	Straight with erect margins
6.3.4 Petiole margins	Winged and clasping the pseudostem	Winged and clasping the pseudostem
6.3.5 **Wing type**	Dry	Not dry
6.3.6 Petiole margin colour	Green	Green
6.3.7 Edge of petiole margin	With a color line along	With a color line along
6.3.8 Petiole margin width	<1 cm	<1 cm
6.3.13 Appearance of leaf upper surface	Shiny	Shiny
6.3.15 Appearance of leaf lower surface	Dull	Dull
6.3.16 Wax on leaves	Moderately waxy	Moderately waxy
6.3.17 Insertion point of leaf blades on petiole	Symmetric	Symmetric
6.3.18 Shape of leaf blade base	Both sides rounded	Both sides rounded
6.3.19 Leaf corrugation	Few stripes	Few stripes
6.3.23 **Blotches on leaves of water suckers**	Large purple blotches	Without blotches
6.4.5 **Peduncle hairiness**	Slightly hairy	Hairless
6.4.9 **Flowers that form the fruit**	Female	Female or Hermaphrodite
6.4.13 **Rachis appearance**	Neutral/male flowers and presence of withered bracts	Bare
6.4.15 Male bud shape	Intermediaire	Intermediaire to Lanceolate
6.5.1 Bract base shape	Medium	Medium
6.5.2 **Bract apex shape**	Obtuse and split	Slightly pointed
6.5.3 **Bract imbrications**	Young bracts greatly overlap	Young bracts slightly overlap
6.5.4 **Colour of the bract external face**	Pink-purple	Purple-brown
6.5.5 Colour of the bract internal face	Red	Red
6.5.6 Colour on the bract apex	Not tinted with yellow	Not tinted with yellow

Descriptors	Plantain	Ainu (Maia Maoli)
6.5.7 Colour stripes on bract	Without discoloured lines on the external face	Without discoloured lines on the external face
6.5.8 **Bract scars on rachis**	Prominent	Not prominent
6.5.9 Fading of color on bract base	Color homogenous	Color homogenous
6.5.10 **Male bract shape**	0.28 < x/y <0.30	x/y > 0.30 (ovate)
6.5.11 Male bract lifting	Lifting one at a time	Lifting one at a time
6.5.12 Bract behaviour before falling	Revolute (rolling)	Revolute (rolling)
6.5.13 Wax on the bract	Very waxy	Very waxy
6.5.14 **Presence of grooves on the bract**	Moderate grooving	Strongly grooved
6.6.1 **Male flower behavior**	Neutral/male flowers persistent	Falling before the bract
6.6.2 **Compound tepal basic color**	Cream + pink rim at base	Yellow
6.6.3 **Compound tepal pigmentation**	Very few or no visible sign of pigmentation	Rust-coloured spots
6.6.4 - **Lobe colour of compound tepal**	Bright yellow	Yellow
6.6.5 **Lobe development of compound tepal**	Developed	Very developed
6.6.6 Free tepal colour	Translucent white	Translucent white
6.6.7 Free tepal shape	Rounded	Rounded
6.6.8 Free tepal appearance	Simple folding under apex	Simple folding under apex
6.6.9 **Free tepal apex development**	Little or no visible sign of development	Developed
6.6.10 **Free tepal apex shape**	Thread-like	Triangular
6.6.11 **Anther exsertion**	Exserted	Inserted
6.6.12 Filament colour	White	White
6.6.13 **Anther colour**	Yellow	Brown/rusty brown
6.6.14 Pollen sac colour	Cream	Cream
6.6.15 Pollen vitality [%]	Absent	Absent
6.6.16 **Style basic colour**	Cream	White
6.6.17 Pigmentation on style	Without pigmentation	Without pigmentation
6.6.18 **Style exsertion**	Same level	Inserted
6.6.19 - **Style shape**	Straight	Curved twice
6.6.20 **Stigma colour**	Yellow	Bright yellow
6.6.21 **Ovary shape**	Straight	Arched
6.6.22 **Ovary basic colour**	White	White
6.6.23 Ovary pigmentation	Very few or no visible sign of pigmentation	Very few or no visible sign of pigmentation
6.6.24 **Dominant colour of male flower**	Cream	Yellow
6.6.25 Irregular flowers	Absent	Absent
6.6.26 Arrangement of ovules	Four-rowed (more or less)	Four-rowed (more or less)
6.7.5 **Transverse section of fruit**	Pronounced ridges	Slightly ridged
6.7.10 Pedicel surface	Hairless	Hairless
6.7.11 Fusion of pedicels	Very partially or no visible sign of fusion	Very partially or no visible sign of fusion

Descriptors	Plantain	Ainu (Maia Maoli)
6.7.15 **Adherence of the fruit peel**	Fruit does not peel easily	Fruit peels easily
6.7.17 Pulp in fruit	With pulp	With pulp
6.7.20 Fruits fall from hands	Persistent	Persistent
6.7.21 Flesh texture	Firm	
6.7.22 Predominant taste	Mild, slightly tasty or tasteless	
6.7.23 Presence of seed with source of pollen	<5	

Annex 4. Recorded synonyms in DR Congo of UNIKIS accessions

The data are presented in three tables:

Table 1 – Tshopo district in Province Orientale

Table 2 – Bas Uélé and Haut Uélé districts in Province Orientale

Table 3 – Kindu province; Kasaï and Sankuru districts in Western Kasaï province; Tanganyika district in Katanga district; Kwilu and Mai Ndombe districts in Bandundu province; Equateur, Tshuapa, Mongala, Sud Ubangi and North Ubangi districts in Equateur province

In each table, the names of accessions for which no synonyms have been recorded have been omitted.

Table 1

Language / Tribe	Turumbu (+ Lokele / Topoke)	Mbole	Lengola / Mituku	Kumu	Manga	Bali	Ngelema	Ngando / Mbesa
Districts	Tshopo	Tshopo	Tshopo	Tshopo	Tshopo	Tshopo	Tshopo	Tshopo / Tshuapa
► FRENCH								
Pendulous bunch, Giant								
Amakoko I					Amakoko I			
Alobe	Alobe						Ma-bembe-ma-bembe	
Bolomaise	Bolomaise			Mbeu				
Bolomaise Super		Bonkeli		Moemba		Zakombo		
Bonua	Bonua (Liondoli bolome / Bolome)	Bolome		Bonenga / Ongua		Nekwele ogbwo	Losondu	Ifate
Chwachwa	Liondoli bolome	Chwachwa	Amagaba	Chwachwa				Lilendo
Gwaleaume	Gwaleaume				Amakoko III			
Kemali				Ketota				
Lib lowaabokoli	Lib lowaabokoli Mwela mwa ngoy	Okali okoi			Ngia	Asugbe	Mwela mwa ngoi	Bokali okoy
Litolo	Litete (Losau)	Litete (Losau)	Adili (Litete / Losau)	Adili (Magboga / Losau / Litete)	Losau / Asau	Adili (Losau / Asau)	Moikili (Losau)	Molengo
Lokoka						Nekwele	Alinga mboka	Lokoka
Losakala (Bosakaraka I)	Ndika ndika			Losakalaka				
Pendulous bunch, Medium								
Adili (Bodo)	Litete ya / li koko			Losau / Asau		Adili		
Afafi noire	Afafi noire							
Amakoko							Molima	
Amakoko II					Amakoko II			
Egbe-o-mabese II			Nganganga	Mosembele-sembele		Famu, Bogo		

Table 1 (continued)

Language / Tribe →	Turumbu (+ Lokele / Topoke)	Mbole	Lengola / Mituku	Kumu	Manga	Bali	Ngelema	Ngando / Mbesa
Districts →	Tshopo	Tshopo	Tshopo	Tshopo	Tshopo	Tshopo	Tshopo	Tshopo / Tshuapa
Magoma I (Rega)				Amambunge		Mayaya		
Yalisa (Plantain-type 6)								Esende
Yumba			Akwedge			Nekwele		
Yumba noire							Moikili	
Pendulous, Small								
Akpasi					Akpasi			
Angbongbolia						Angbongbolia		
Boofo	Boofo		Evandakala					
Boofo noir	Boofo noir		Evandakala	Negwandobungu	Tatalikoko	Tondolitondo		
Ifel(eng)ete ya bolome							Ifelengete / Ifelete ya bolome	
Subhorizontal bunch, Medium								
Katutu	Nguku							
Subhorizontal bunch, Semi-Dwarf								
Amuku	Amuku / Amungu			Amungu				
► **FALSE HORN**								
Pendulous bunch, Small								
Imbe	Imbe(le)nga			Akoto			Imbenga	Londombe (Malomi / Maluma)
Amakake		Amakake		Amakake		Ligo (Akoshango)	Ifelengete	Ifelengete

Table 1 (continued)

Language / Tribe →	Turumbu (+ Lokele / Topoke)	Mbole	Lengola / Mituku	Kumu	Manga	Bali	Ngelema	Ngando / Mbesa
Districts →	Tshopo	Tshopo	Tshopo	Tshopo	Tshopo	Tshopo	Tshopo	Tshopo / Tshuapa
Subhorizontal bunch, Medium to Giant								
Apoka	Libanga ya koko, Ifondo (Topoke)					Awungu		
[illegible]	[illegible]		Nganganga	Mosembele-sembele	Angia	Angia, Famu	Mocheche	Mbulu
Libanga dark green						a-Mbulu, Adili		
[illegible]	Libanga Mombo	a-Mbulu	Avuka, Ambulu	Ka-sombo Ambulu	Sombo, Wombo	Wombo, Sombo	Sombo, Ambulu	
[illegible]	Libanga likale Ambulu, Ebanga	a-Mbulu Inamba	Avuka Ambulu	Ambulu, Akocha, Avuka	Ngene	Akoto, Ngene, a-Mbulu,	a-Mbulu, Akaka, Ebanga	a-Mbulu
Libanga multiple	Libanga multiple							
Libanga noire	Libanga noire			a-Mbulu		Akoto		
Lingu			Lingu	Manimani		Akoshango		
Subhorizontal bunch, Semi-Dwarf								
Apoka magbuge			Odemage					Bamuku
[illegible]	[illegible]				Nkalia			
► **HORN**								
Pendulous bunch, Medium								
Lokusu	Lokusu / Bombili	Lelonga		Elonga			Esambo	Etate
Subhorizontal to erect bunch								
Ikpolo	Losase	Losase / Bombili	Bombili	(ki)-Chanja moya				
Ikpolo noire	Ikpolo / Bokwoto				Chwambo			

Table 1 (continued)

Language / Tribe →	Turumbu (+ Lokele / Topoke)	Mbole	Lengola / Mituku	Kumu	Manga	Bali	Ngelema	Ngando / Mbesa
Districts →	Tshopo	Tshopo	Tshopo	Tshopo	Tshopo	Tshopo	Tshopo	Tshopo / Tshuapa
«poilo rouge»	[illegible]							
Moikili							Moikili	Molembo / Molengo
Tam Isai	Tshi kila		Ngulu					

Table 2

Language / Tribe ·	Benza	Zande / Benge	Budu	Lese	Ngbetu	Logo
Districts ·	**Bas Uélé**	**Bas Uélé**	**Haut Uélé**	**Haut Uélé**	**Haut Uélé**	**Haut Uélé**
► FRENCH						
Pendulous bunch, Giant						
Amakoko I					Abita	
Aleke	Ma-bembe-ma-bembe	Keichru	Angbembe		Nahi	Mbèmbé
Bolomaise		Enguse	Linyaise		(ne)Gondolo	Anzodoko
Bosakaraka	Akonje			Andula	Andula	
Bosua				Agbindolo	Ekpadjoro	
Chwachwa	Gbagbanga Bu	Gbagbanga Bu	Gbondo	Rambi	Esugbe	Akulisi
Kpoolo	Kpoolo					
Kodje					Kodje	
Lib liboelabokoi)	Mbala	Mbongo, Ngbulu ma-mbongo		Amabunukege	Agendoo	
Lindimama	Lindimama					
Litete	Mapipi (Losau)	Mapipi (Libobi)	Osiangbe	Angbindola	Nekpanjoro (e-Mbindo)	
Losakala (Bosakaraka I)					Manziboli, Nemanzili	
Mongele	Madame					
Wangwa		Wangwa				
Pendulous bunch, Medium						
Adili (Bodo)			Osiangbe			
Alati noire	Aleha					
Alati wine-red					Mbindo	
Bhegisi				Bhegisi	Bhegisi	
Bondele		Bondele				
Bu Ambala	Bu Ambala					

Table 2 (continued)

Language / Tribe →	Benza	Zande / Benge	Budu	Lese	Ngbetu	Logo
Districts →	Bas Uele	Bas Uele	Haut Uele	Haut Uélé	Haut Uélé	Haut Uélé
Egbe-o-mabese II			Egbe-o-mabese II	Djagba		
Kambolokoso (Rega)	Gbagbalatala					
[illegible]	[illegible]	Maboto		Makindikindi		
Magoma II					Bagbu	
Ongwa		Enguse Mutani				
Sika	Sika	Bu Sika				
Sugbe	Sugbe				Gbumeupe	
[illegible]					Bebere	
Yumba noire	Manzelepete	Mobwete				
Pendulous, Small						
Akpasi		Nagbeke / Akpeta		Nemakete		
[illegible]	[illegible]					
Boofo					Osumba	
Boofo noir					Nayebhu	
[illegible]	[illegible]					
Gwekwele	Gwekwele					
Subhorizontal bunch, Medium						
Bakpala	Bakpala					
[illegible]			Nemakete		Marangbai	
Masekpe	Masekpe					
Subhorizontal bunch, Semi-Dwarf						
Akoy				Akoy	Akoy	
Amuku				Angbindolo munzu		

Table 2 (continued)

Language / Tribe →	Benza	Zande / Benge	Budu	Lese	Ngbetu	Logo
Districts ↓	Bas Uélé	Bas Uélé	Haut Uélé	Haut Uélé	Haut Uélé	Haut Uélé
► FALSE HORN						
Pendulous bunch , Small						
Akoto			Malewa		Ma(n)gbue	
Amakake					Ngbulu kikere	
[illegible]	Bubanga	Mobwete				
Subhorizontal bunch, Medium to Giant						
Apoka	Engbau, Abukianakete (Benza)	Abukianakete	Apoka			
[illegible]	Ngumbi, Muchuche (Benza)	Mandoloto, Ngondi	Apoka linyenguu		Ne-bodhobodho	Amachachacha
Libanga dark green			nema-Ngbulu, Mangbenlendu		nema-Ngbulu, maNgbulu	
Libanga lifombo	Ngbulu, Sumbu (Benza)	Gumba / Ngbulu mogbama				
[illegible]	Ngbulu, Mobou (Benza)	Ngbulu / Ngbulu mabembe	Abidhotage	ma-Ngbulu	ma-Ngbulu, Abidhotage	ma-Ngbulu
Libanga multiple	Fondo, Dragona (Benza)	Bozobiate				
[illegible]	Likondo mwafu (Benza)	Ngbulu manzele-pele	Ma-gbolo-koto	ma-Ngbulu	Embilanga	ma-Ngbulu
[illegible]			Makolokoto, Osi linguu		Makolokoto	
Mangweangwea	Mangweangwea	Mangweangwea				
Nebundu					Nebundu	Nepuka
Subhorizontal bunch, Small						
Leese	Lese	Lese				

Table 2 (continued)

Language / Tribe →	Benza	Zande / Benge	Budu	Lese	Ngbetu	Logo
Districts →	**Bas Uélé**	**Bas Uélé**	**Haut Uélé**	**Haut Uélé**	**Haut Uélé**	**Haut Uélé**
Subhorizontal bunch, Semi-Dwarf						
Bokpeta	Galwe	Momudalagbia			Kpadjoro	
[illegible]	[illegible]	[illegible]				
► HORN						
Pendulous bunch, Medium						
Lokusu		Galwe		Mogo adhikeke		Mangongo na ngonde
Lokusu red	Ebotave					
Mongo						Mongo
Pendulous bunch, Small						
Nselenge	Ngonde	Ngondima				
Subhorizontal to erect bunch						
[illegible]		Gbagawa				
Ikpolo noire				Pembe na nzoku	Ozute	
Ikpolo rouge			Itaka migana	Bhango	Ozute	
[illegible]	Huwa	sa-Ngbulu kwali / Ependa	Ungekpe	Ngbikpi	Nangbikpi	

Table 3

Language / Tribe →	Kumu	Songola	Luba	Kongo	Mongo	Mbuza	Ngombe
Districts →	Kindu	Kindu	Kasaï / Sankuru / Tanganyika	Kwilu / Mai Ndombe	Equateur / Tshuapa	Mongala	Nord / Sud Ubangi
► FRENCH							
Pendulous bunch, Giant							
[illegible]					Akokailongo		
Amakoko I		Ilonga lokuchu					
Aleke	Kainganya	Mobinge(le)			Mudinga	Monziki	Simbaki
Atili		Atili					
[illegible]						Boleko	
Bolomaise	Mbungu		Nyengele			Mogele	Gengu
Bolomaise Super	Moemba		Djeke Kamesuko				Bokumu
Bokoka Lilongo					Bongboki	Bokoka Lilingo	
Bosakaraka					Elombo		
[illegible]	Ekoko Akua	Yomabombe (Simbakimbi)	Aleta		Loengenge	Engbele	
Inekelekumi					Ngboku		Egbu
Lib Ibeelabokoi)		Kengbekengbeke	Etshuma kawelo				
Litele	Bonjilo (Gase)	Bonjilo bene		Mimbuka	Lolipili	Abu	Emboye
Losakalu (Bosakaraka I)	Ikosa	Ngoi				Mbongo	Bokumu
Yeli							Yeli
Pendulous bunch, Medium							
Adili (Bodo)	Gase amaimboya	Bonjilo			Bolifiti		Bondjolo
Alatu ngele	Ekitasina	Amaibu Mwabi				Hindi	
[illegible]					Nguya	Eyondo	
Akadja						Akadja	
Amakoko II	Amakoko						Mokenge

Table 3 (continued)

Language / Tribe →	Kumu	Songola	Luba	Kongo	Mongo	Mbuza	Ngombe
Districts →	Kindu	Kindu	Kasaï / Sankuru / Tanganyika	Kwilu / Mai Ndombe	Equateur / Tshuapa	Mongala	Nord / Sud Ubangi
Kambolokoso (Rega)	Djaikonde (Amaiganga)						
Lolipili					Lolipili		
Luzi		Luzi	Ongongo Yandjala				
Magoma I (Rega)	Amamundu	Kyobe					Mongobe
Ongwa I					Mongobe		
Yelola (Plantain rouge II)	Bowakobolobo	Aluba					
Yumba	Amagbada	Sembe					
Pendulous, Small							
Akpasi	Kinjao						Mokona
Amagaba	Amagaba						
Boofo			Kanyongolo		Kotoma		
Boofo noir	Nyuki, Nqwandobungu				Elombo muke	Boosa	
Kenjala		Kenjala					
Manimani	Manimani [81]						
Ngindaolo					Ngindaolo		
Subhorizontal bunch, Medium							
Katutu		Katutu					Embolokoto
Yungu		Yungu					
Subhorizontal bunch, Semi-Dwarf							
Amubu	Amungu					Ngbangbo	

Table 3 (continued)

Language / Tribe	Kumu	Songola	Luba	Kongo	Mongo	Mbuza	Ngombe
Districts	Kindu	Kindu	Kasaï / Sankuru / Tanganyika	Kwilu / Mai Ndombe	Equateur / Tshuapa	Mongala	Nord / Sud Ubangi
► FALSE HORN							
Pendulous bunch, Medium							
Mogbokuma			Shenga dikondo		Mogbokuma		
Pendulous bunch , Small							
[illegible]	Akmo		Dimonga				
Amakake	Amakake						Mobedu
Babele bapoku					Babele bapoku		
Subhorizontal bunch, Medium to Giant							
Apeka	Mokombe				Limpata	Yondo	Bopoko
[illegible]	Amasungu Aunga-Ama mokongodo, Mayuyu	Mobondju, Mogogo	Kalunga mbumba	Moasi	Mbuli	Motchetche	Ngbongale
Libanga dark green	a-Mbulu					Mbudi	Embanga mobondo
Libanga Mombo	Ka-sombo, Ambulu		Kamatadji		Bosukuangola	Sombo	Sombo
[illegible]	Akoo, Abholo-	Kokoo	Makondji mampadji	Ntsila	Embanga	Ebanga	Embanga
Libanga multiple					Ikondo		
Libanga noire	a-Mbulu	Kondo			Ebanga		Abu to mbuma
Lingu	Eke	Kanjelu					
Mangweangwea					Pembe		
Mongobe					Mongobe		
Taena pambe		Taena pambe					

Table 3 (continued)

Language / Tribe →	Kumu	Songola	Luba	Kongo	Mongo	Mbuza	Ngombe
Districts →	Kindu	Kindu	Kasai / Sankuru / Tanganyika	Kwilu / Mai Ndombe	Equateur / Tshuapa	Mongala	Nord / Sud Ubangi
► HORN							
Pendulous bunch, Medium							
Lokusu	Lelonga/Mogomba	Bosinda					
Lokusu red			Djilume				
Pendulous bunch, Small							
Nselenge					Nselenge		
Subhorizontal to erect bunch							
Bokangasoku	Kaumbwa						
[illegible]			Makonda	Nkombe	Mopanza		
Ikpolo noire			Pidima noir				
Ikpolo rouge	Mbuli	Mbudji	Makonda bianza	Mbuli			
[illegible]					Yekekonch		
[illegible]		Lopema			Lokolojonto	Ndendaliko	Bosodiko

Annex 5. The practical plantain cultivar differentiation system at UNIKIS

Dot lines separate the clusters of variants of the underlined main types.

Name	Description (suckers)
French	
Giant	
Bosakaraka I	Bunch with ≥ 12 hands, salient and outward bending fingertips
Andula	Bosakaraka I with black pseudostem
Boleko	Bosakaraka I with white streaks on the pericarp
Bosakaraka II	Bosakaraka I with blunt apex
Chwachwa	9-12 hands. Fingers larger than Bosakaraka I
Bosua	Chwachwa with red pseudostem
Litete	Dark green pseudostem and fingers
Atili	Litete with white streaks on the pericarp
Lokoka	The inner side fingers very intermingled
Akoka-ilongo	Lokoka with green fruit peel at emergence progressively becoming red with the maturity
Bolomaise	Lokoka with slightly angled bunch with 9-12 hands, blunt fruit apex
Bokoka Liloka	Bolomaise with red pseudostem
Mongele	Lokoka with red pseudostem with yellow fruit peel before maturity
Wilingwa	Lokoka with 2 or 3 suckers just before the male bud
Yeli	Lokoka with yellowish pericarp before maturity
Amakoko I	Intermediate finger apex
Kpoolo	Amakoko I with red pseudostem
Lindimama	Very blunt apex; short fingers for a giant
Kodje	Very compact bunch with bottle-necked finger apex
Aleke	Spiraloid bunch
Unusual variants	
Libanga Liboelabokoi	Monoserial
Libanga Lib. red	Libanga Liboelabokoi with red pseudostem
Ketota	Libanga Liboelabokoi with yellow fruit peel before maturity
Inekeleikumi	Unusual finger form for plantains: short, fat and completely straight with intermediate apex
Medium	
Yumba	Prototype of medium French plantain with slightly curved fingers
Sika	Yumba with black streaks on pericarp
Bhegisi	Sika with black pseudostem
Yumba Black	Yumba with black pseudostem
Afati	Red pseudostem and finger-tips bending outwards (abaxially)

Name	Description (suckers)
Afati 'Wine Red'	Afati with weak red fruit peel at the emergence, becoming wine-red at maturity
Afati Black	Afati with black pseudostem
Luizi	Afati with green pseudostem and yellow fruit peel before maturity
Ongua	Afati with green fruit-peel colour at emergence, which progressively becomes red at maturit
Sugbe	Afati with red leaves, green salient fruits
Yelola	Afati with bright red fruit-peel at emergence, becoming rusty-red at maturity
Akadja	Medium variant of Litete (see Giant)
Lolipili	Akadja with red petiole margins
Magoma I	With blunt apex. Medium form of Lindimama (see Giant)?
Magoma II	Magoma I with outward bending fingertips
Adili	Magoma I with dark green pseudostem and fingers with blunt apex
Masekpe	Medium Kodje (see Giant)
Bakpala	Masekpe with red pseudostem and sub-horizontal bunch
Amakoko II	With intermediate finger apex and outward bending fingertips
Unusual variants	
Bu Ambala	With 1 finger per hand
Bondele	Buambala with yellowish finger colour
Egbe-O-Mabese II	Hornlike fingers, neutral-and-male inflorescence French-like, but male bud exhausting at late stage
Kambolokoso	With pronounced wrinkle on the fruit
Maboto	With long pedicel which is unusual in plantain
Small	
Boofo	Fingers perpendicular to floral axis and arched
Boosa	Boofo with black pseudostem
Boofo Red	Boofo with red pseudostem
Manimani	Boofo with yellowish immature fruit peel
Akpasi	Boofo with shorter fingers, rather perpendicular to floral axis
Angbongbolia	Boofo with blunt finger apex
Gwekwele	Fingers parallel to the floral axis, with rigid pedicel
Engwe	Gwekwele with wine-red fruit peel colour
Ifel(eng)ete Ya Bolome	Gwekwele with black streaks on the pericarp
Ngindaolo	Gwekwele with blunt apex
Amagaba	Long fingers for small plantain on very lax bunch
Kenjala	Red pseudostem, intermediate finger apex;slightly waxy peel
Semi dwarf	
Akoy	Blunt apex
Amuku	Akoy with red pseudostem
Dwarf	
Nguku	Dwarf Medium with a compact bunch
Yungu	Nguku with a red pseudostem colour

Name	Description (suckers)
False Horn	
Medium	
Libanga Likale	Prototype of False Horn. Asymmetric finger orientation points to sub-horizontal trend, but the bunch looks pendulous at maturity
Libanga Lifombo	Libanga with red pseudostem. Trend to Giant form
Libanga Black	Libanga with black pseudostem
Libanga Dark Green	Libanga with dark green pseudostem and fingers
Kese	Libanga with black streaks on the pericarp
Mangweyangweya	Libanga with white streaks on the pericarp
Mongobe	Libanga with green fruit-peel at emergence, becoming progressively red with the maturity
Nembundu	Libanga with wine-red fruit peel at maturity
Mogbokuma	Libanga with curved fingers like horn
Libanga Multiple	Libanga with bunch split in 2 or more
Apoka	Libanga Likale with blunt apex
Lingu	Clearly pendulous bunch with yellowish immature and curved fingers
Taena Pambe	Clearly Sub-horizontal bunch with blunt apex finger apex
Egbe-O-Mabese I	Resembling Egbe-O-Mabese II (cf. French medium) but with only a few relict bracts at the end of the exhausting rachis, typical for False Horn
Small	
Leese	Small form of Libanga Likale (False Horn Medium)
Babele Ba Poku	Yellowish immature and straight fingers on pendulous bunch
Amakake	Fingers perpendicular to floral axis and arched
Akoto	Quasi-blunt finger apex; pendulous bunch
Boon	Akoto with straight fingers
Bubungu	Akoto with swollen/fleshy flower-rests on finger apex
Semi-dwarf	
Bokpeta	Semi-dwarf Libanga with substantially longer male inflorescence
Mumuliagbia	Bokpeta with a horizontal bunch and shorter fingers
Apoka Magbuge	Short and 'fat' fingers, with almost blunt apex and dried flower vestiges
Horn	
Giant	
Ikpolo	Horizontal to erect fingers
Ikpolo Black	Ikpolo with black pseudostem
Ikpolo Red	Ikpolo but red pseudostem
Moikili	Ikpolo with dark green pseudostem and finger
Bokangasoku	Ikpolo with a single straight and radically ageotropic hand
Medium	
Lokusu	Pendulous, long fingers; yellowish immature pericarp; green pseudostem, 2-4 hands, with first hand pointing horizontally, other hands rather downwards but still arced

Name	Description (suckers)
Lokusu Red	Lokusu with red pseudostem
Mongo	Lokusu with more than 4 hands
Small	
Nselenge	Pendulous bunch with fingers perpendicular to the inflorescence axis
Dwarf Giant	
Tala Lola	Dwarf form of Ikpolo

Annex 6. Photographic illustration of the cultivars representing the salient differences

The photos correspond with the underlined accessions in Annex 5. These accessions represent the essential plantain diversity, while the others are rather minor variations.

Each picture tries to catch one or more typical features. But not all of the critical descriptors for the cultivar can be shown in one single picture, and interested readers are invited to contact the first author of this book for more details.

French Giant

Akpa

Onwuchwa

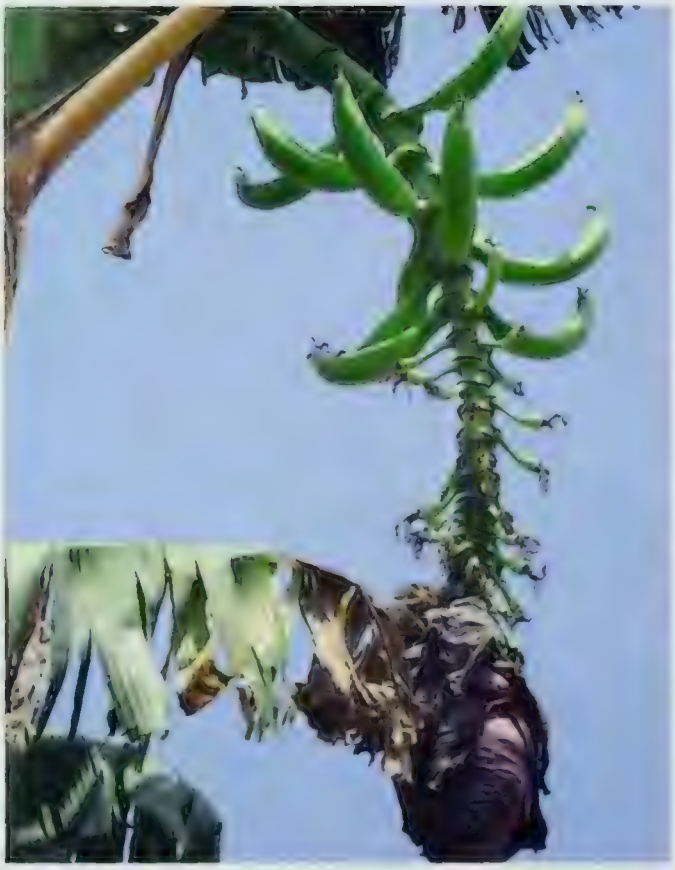
Libanga Liboelabokoi

Litete

Lokoka

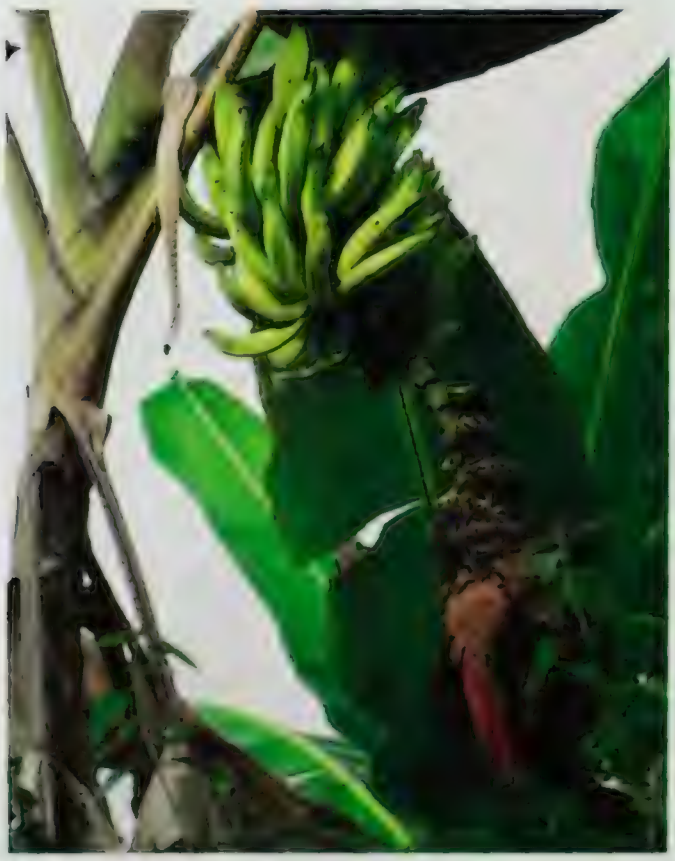
Losakala

French Medium



Bu Ambala

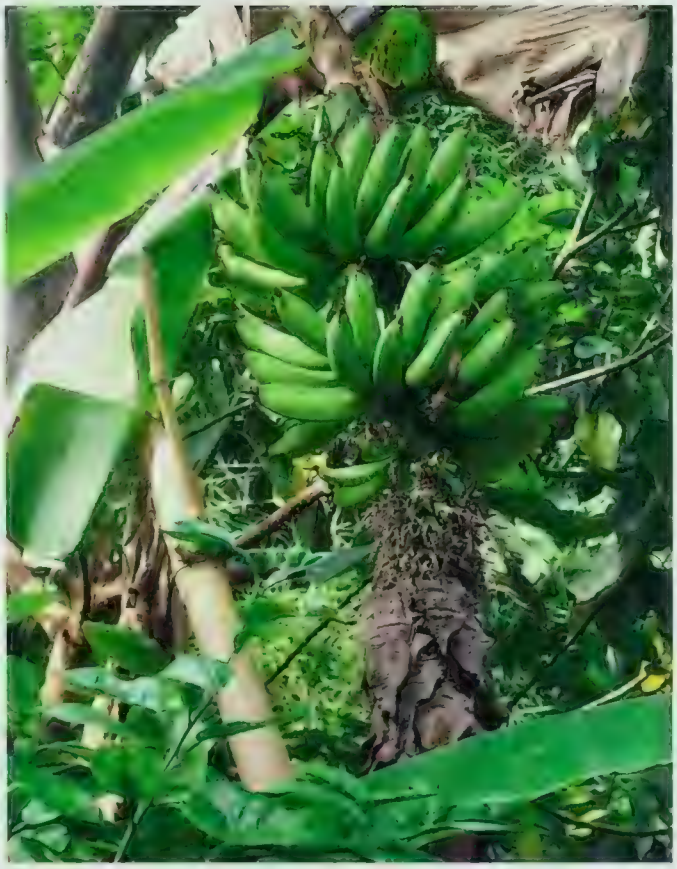
Egbe-O-Mabese II



Luzi

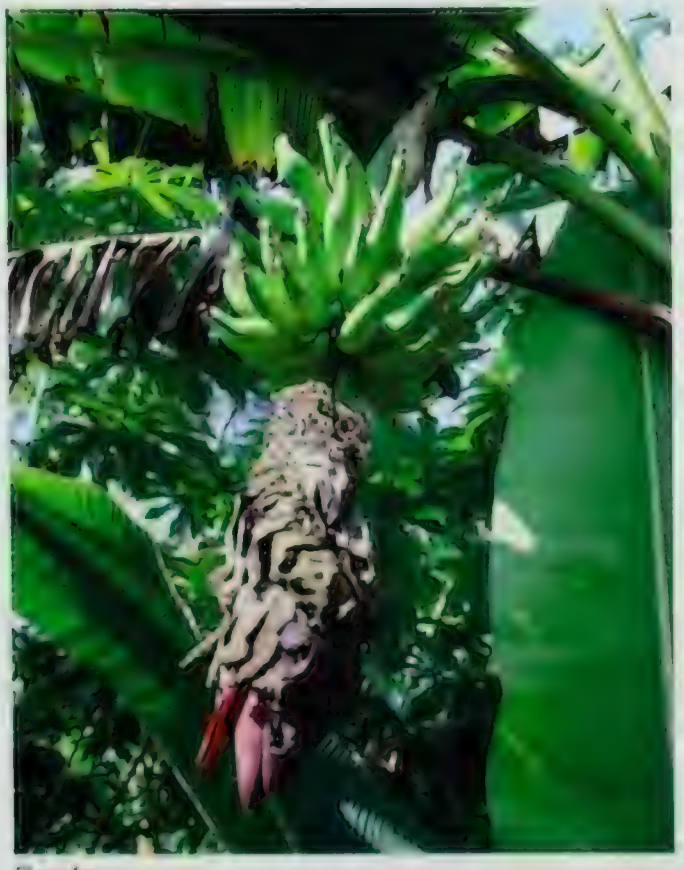
Magoma I

Yumba



Yumba black

French Small



Bonfo

Gwekwele

French Semi-dwarf

Akoy

French Dwarf

Nguku

False Horn Medium

Lituanya Likoie

Ajonua

False Horn Small

Leese

False Horn Semi-dwarf

Bokweta

Horn Giant

Ikpolo

Horn Medium

Lokusu

Horn Small

Nselenge

Horn Dwarf

Tala Lola

Scripta Botanica Belgica **54**

Characterization and classification of the *Musa* AAB Plantain subgroup in the Congo basin

J. Adheka Giria & E. De Langhe

The starchy Plantain banana is a basic staple food crop in humid tropical Africa, where its cultivation during many centuries produced a huge and unique cultivar diversity through multiple somatic mutations. This book describes and classifies the cultivars of the Democratic Republic of Congo (DR Congo). During the first phase, which took place in the 1950s and was limited to what is now the Tshopo province, 56 cultivars were already collected and grown at the Yangambi agricultural research centre. The resulting taxonomic publications were of great help for the recent second phase from 2005 to 2012, during which 97 cultivars of plantain were collected in 294 villages in 9 out of 11 provinces of the country. The corresponding accessions were established in the field collection at the University of Kisangani (UNIKIS). The identification of the numerous synonyms and a conciliation between the data from the Yangambi and UNIKIS collections resulted in a documented basic list of 119 DR Congo plantain cultivars. This will be a guide for all future plantain taxonomical and breeding work in the country, as well as a firm reference for similar taxonomic research at the pan-African scale.

Dr. Edmond De Langhe is Professor emeritus in Tropical Crop Improvement at the Katholieke Universiteit Leuven. He initiated the taxonomy and genetic improvement of the Plantain banana in DR Congo and later became the Director of the International Network for the Improvement of Banana and Plantain (INIBAP), coordinating banana research at the global level.

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ISBN 9789492663146
ISSN 0779-2387
D/2018/0325/001